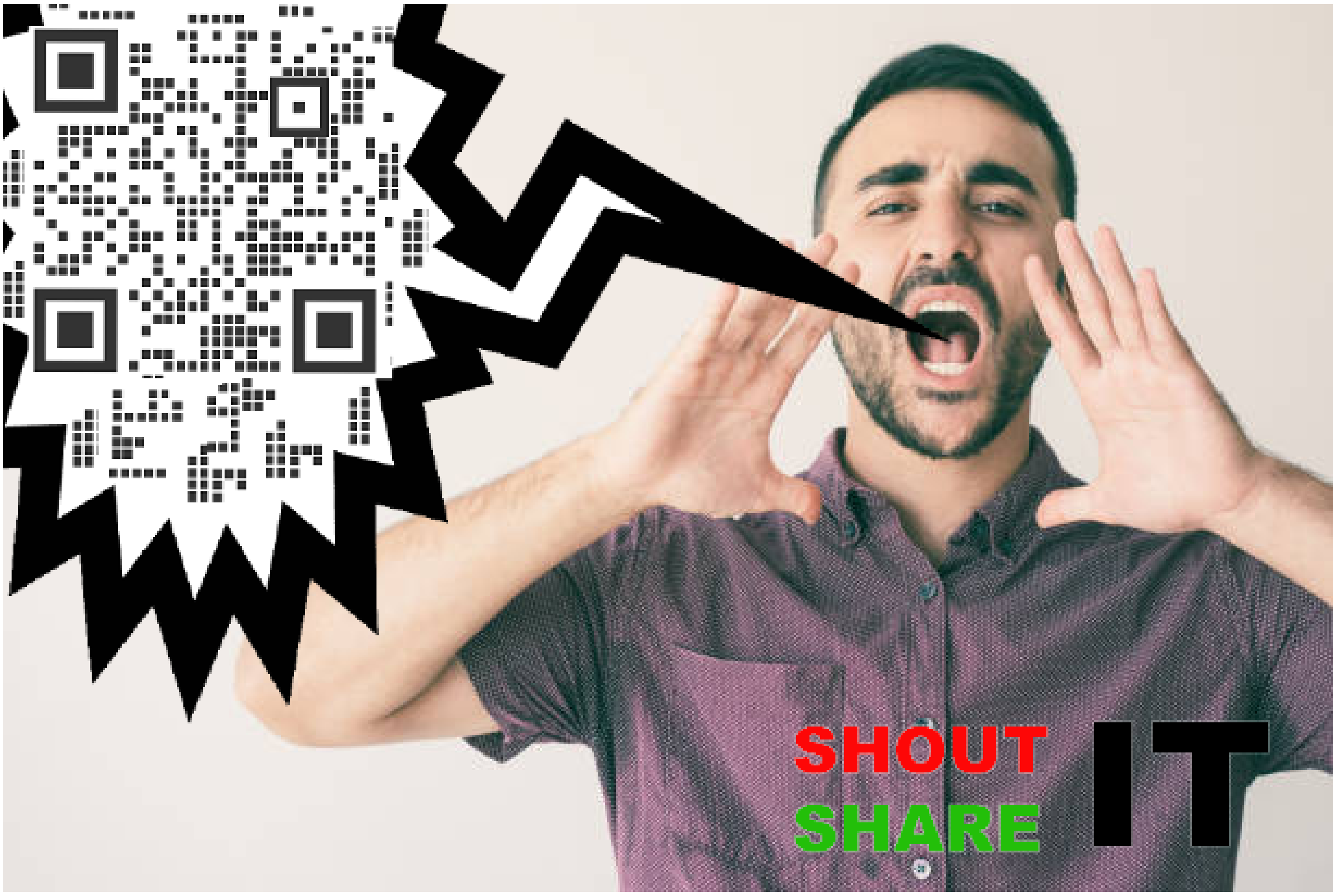
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NATURE IN AVON

PROCEEDINGS OF THE BRISTOL NATURALISTS' SOCIETY, 1989

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NATURE IN AVON

THE PROCEEDINGS OF THE BRISTOL
NATURALISTS' SOCIETY

VOLUME 49

1989

EDITED BY P. R. CROWTHER
ASSISTED BY A COMMITTEE

"*Rerum cognoscere causas.*"—VIRGIL.

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VOLUME 49
CONTENTS

GENERAL & SECTIONAL PROCEEDINGS

Council, 1989 2
Editorial 4
Report of Council, 1989 5
General Meetings, 1989 6
General Field Meetings, 1989 6
Report of the Botanical Section, 1989 7
Report of the Geological Section, 1989 8
Report of the Ornithological Section, 1989 9
Library Report, 1989 9
Obituary: Thomas Everett Thompson (1933-1990) 10
Statement of Accounts for the year ended 31 December 1989 .. 12

BRISTOL BIOTA

Avon & District Entomological Report, 1989 14

Avon Mammal Report, 1989 19

Bristol Botany in 1989 31

ORIGINAL PAPERS

Small Mammals in a Species-rich Hedgerow in Avon, by D. P. C. Trump 43

Effects of the Addition of Mineral Nutrients on the Vegetation of the Avon Gorge, by A. J. Willis 55

The early Ordovician Trilobite *Beltella*, by R. A. Fortey and R. M. Owens 69

PAST PRESIDENTS 80

EDITORIAL

The appointment of a new editor is always a cue for acknowledging the contribution of the previous incumbent. In the case of Mr Allan Frey, who became Editor in 1986, this is especially appropriate because Allan and his Publications Committee were responsible for a minor revolution in both the appearance and the content of our *Proceedings*. He oversaw the creation of the first two 'thematic issues' in the Society's long history: for 1987 on *The Avon Gorge* (published in 1989) and for 1988 on *Bristol's Urban Ecology* (published in 1991). These were targeted not only at the Society's members but also at the general book-buying public; both Allan and the Society's printer, Mr Adrian Grenfell, expended much effort in producing these and marketing them to commercial outlets in Bristol and also further afield. It is a credit to their talents that, at the time of writing, *The Avon Gorge* is virtually sold out.

This issue of the *Proceedings* (for 1989) reverts to the traditional format, with three very different original papers and the usual reports of the Society's annual programme. The paper by Mr David Trump gives a progress report on his part in a national study of the importance of hedgerows to small mammals. Professor Arthur Willis contributes a detailed account of the effects of mineral nutrients on the plant life of the Avon Gorge; he identifies the factors which limit production and so ensure the continuing species richness of the flora, with its many rarities. Drs Richard Fortey and Bob Owens demonstrate how effortlessly palaeontologists can use fossils to track whole continents across the face of the earth through geological time; their taxonomic revision of a small trilobite from the Early Ordovician rocks of the Tortworth area leads to a comparison with Canadian examples which in turn suggests a palaeogeography very different from the world of today.

Of the three reports on biota, that on Bristol botany, compiled as usual by Professor Willis, follows the normal pattern. In the Entomological report Mr Ray Barnett departs from past practice by concentrating on a single group and synthesizing the available knowledge on the distribution of the various species of Ladybird found in the district. The Mammal report, compiled by Mr Roger Symes and Mr Trump, also breaks new ground, summarizing ten years' data on individual species but reporting too on changes in legislation, mammals as pests, studies in progress and practical conservation and rehabilitation activities. The number of organisations official and unofficial, and of individuals, involved with mammals in Avon will surprise many readers.

The camera-ready copy for the present issue was produced on computer and laser printer (another first for the Society), thanks particularly to the efforts of Mr Michael Taylor and with the help of Dr Harvey Rose. This break with past practice gives me the opportunity to thank Adrian Grenfell for so thoughtfully organising the production and printing of the *Proceedings* in past years.

The next two issues of the *Proceedings* will be devoted to the themes *The Coast of Avon* (for 1990) and *Conservation in Avon* (for 1991). Your Publications Committee is very aware that the *Proceedings* are produced for the benefit of the Society's membership, so any comments on past issues or on our future plans will be most gratefully received.

Dr Peter R. Crowther
Hon. Editor
9 May 1991

REPORT OF COUNCIL, 1989

Membership at the end of 1989 was 532. At the Annual General Meeting on January 21st the Officers and Members of Council were elected with Miss Rachel C. Lee as President.

The Society is represented on the Severn Estuary Conservation Group and has opposed the proposed Cardiff Bay Barrage Bill which will, in effect, destroy a number of Sites of Special Scientific Interest. At an appropriate time members will be asked to write to their Members of Parliament to object. The RSPB and the Save the Taff Group were preparing an alternative scheme which would not disrupt the SSSIs. The Society is also represented on the Leigh Woods Management Committee.

The Hector Hockey Fund supported the following: a survey of freshwater invertebrates in the Gordano Valley; monitoring of butterfly populations in the Lower Woods; the publication of two papers in the *Proceedings*; and the Somerset Flora Project.

Strenuous efforts have been made to increase public awareness of the Society's activities, and Council expresses its thanks to Bristol Central Library for circulating our publicity posters to the various public libraries in the city. The latest issue of the *Proceedings* - special issue on *The Avon Gorge* - was published in a new format and sales to the public have increased. A Publications Fund has been set up to further the production for sale of reprints of papers from the *Proceedings* and of other original pamphlets.

A set of "Guidelines for leaders of Field Meetings", outlining responsibilities, has been produced. Chairmen of indoor meetings have been advised on procedures.

The practice of holding some winter indoor meetings on Saturday afternoons has proved popular and will be continued. Formal activities by the Entomological Section have been temporarily suspended and Mr R. M. Payne has answered enquiries during 1989.

We record with regret the deaths during 1989 of Mrs J. Appleyard, Mr A.E. Billett, Mrs I.M.H. Frost, Mrs V.J. Kenney, Mr H.R.H. Lance and Sir Peter Scott, and on 1 January 1990 of our immediate past-President Dr T.E. Thompson.

Sir Peter Scott CH CBE DSC who died in August shortly before his eightieth birthday had been a member since 1947. His many talents and his international and national achievements have been chronicled elsewhere; here we note that a lecture he gave to the Ornithological Section in February 1937 had momentous consequences: the Section Secretary, H. H. Davis, kept in contact with him and after the war invited him for a weekend to study the wild geese wintering on the New Grounds near Slimbridge. On December 16th 1945 they found seven species, including two individuals of the extremely rare Lesser White-fronted Goose, and Scott decided that this must be the site of the wildfowl organisation he had dreamed of forming. The result was the Severn Wildfowl Trust, now the Wildfowl and Wetlands Trust.

Mrs J. Appleyard, a member from 1966, died on June 26th at an advanced age. She was a bryologist with a national reputation; her contributions are summarised on page 32, in the Report on Bristol Botany for 1989. She led a number of field meetings for the Society to study bryology, especially in Ebbor Gorge.

A. E. **Billett**, a member since 1940, died on November 8th aged 84. He had served the Society for many years as Honorary Auditor, on committees, leading field walks and organising fieldwork. He was the last of a notable quartet of members (the others were S. H. G. Barnett, A. C. Leach and H. W. Neal) who through many years of retirement had shared a day's birdwatching each week.

Mrs V. Joyce Kenney joined the Society in 1946. A loyal and hard-working member over many years and active until shortly before her death on December 17th, she had served for long periods on the Field and Library Committees (chairing the former from 1984 to 1988) and on Council. She led many field meetings, and as an enthusiastic naturalist shared with members her interest in all aspects of the terrain covered. It was her idea in the mid-1980s that the Society take part in Avon County Council's "Walking in Avon" scheme and she made her own contribution to the walks that were arranged.

H. R. H. Lance, who died on December 1st aged 70, had been a member since 1952. A keen ornithologist and bird ringer, he served on the Ornithological Section Committee, and was its Secretary from 1970 to 1972.

A memoir of **Dr T. E. Thompson** appears on pages 10-11.

AUDREY HECKELS, *Hon. Secretary.*

GENERAL MEETINGS, 1989

21 Jan.	Annual General Meeting & Presidential Address - "Marine biology in the Mediterranean Sea", by Dr T. E. Thompson.
23 Feb.	"New Zealand: a paradise for naturalists", by Mrs P. Hill-Cottingham.
11 Mar.	"Thirty years of work on Lough Hyne", by Dr C. Little.
13 Apr.	Annual buffet supper - "Trees in and around Avon", by Mr A. C. Titchen.
22 Apr.	"An approach to understanding insect diversity", by Dr A. C. Neville.
5 Oct.	"Farm woodlands", by Mr Huw Davies.
2 Nov.	"Dormice", by Mr Paul Bright.
7 Dec.	"Conservation in Bristol's parks", by Ms Kim Davies and Ms Sophie Price (Bristol City Council).

AUDREY HECKELS, *Hon. Secretary.*

GENERAL FIELD MEETINGS, 1989

11 Feb.	Mr D. A. Cullen. Clevedon Sea Wall. A sunny morning in the middle of a very mild winter. An exceptionally high tide meant that there were huge flocks of Dunlin in an aerial roost, finally settling on the rocks exposed by the receding tide. Members saw preparations for netting and ringing waders.
24 Mar.	Miss M. Jervis. Wye Valley. A walk from Bigsweir up to Pen-y-Fan then down to Whitebrook and along the disused railway track to Redbrook. Many flowers seen in what was an exceptionally early season.
22 Apr.	Mr D. A. Cullen. A rewarding visit to two contrasting habitats. First to the bank of the R. Usk, with views of Sand Martins excavating nests, two Green Sandpipers on passage, a Peregrine Falcon and many common birds. Then to Nag's Head Plantation in the Forest of Dean, for good views of Pied Flycatchers, Redstart, Nuthatch, warblers and tits.

20 May	Miss S. Garden. Stourhead. A morning visit to the gardens, which were at their peak of spring colour and beauty. An afternoon walk up nearby White Sheet Hill, a large area of chalk downland, with much of the typical flora.
23 May	Mr D. A. Cullen. Inglestone Common. A cool, still evening after a very hot and humid day. Much bird song, including Nightingales and many of the warblers. Many woodland flowers.
6 Jun.	Mr L. A. Cram. Cheddar Gorge. A walk up the left side of the Gorge, from opposite Black Rock Gate, through woods to the open cliff top, seeing many flowers on the way including several Cheddar rarities. Excellent views.
24 Jun.	Drs. N. Malcolm and J. Rees. Kenfig Burrows, South Wales. Many of the flowers for which Kenfig is known were seen, including amphibious bistort, true bulrush, bristle club-rush, common lesser water plantain, southern marsh orchid, fen orchid, early marsh orchid, sea holly, Welsh evening primrose, round-leaved wintergreen and broad-leaved helleborine.
15 Jul.	Mr Bernard Storer. The Somerset Trust's Westhay Reserve, Somerset Levels. The peat workings were explained, and also the Trust's plans for further developments to attract birds and plants. A Nature Conservancy Council reserve consisting of two fine hay meadows was also visited.
9 Sep.	Dr N. Webb. Stoborough Heath and Hartland Moor, Dorset. The structure and ecology of the heath was explained, also the effects of the very dry summer on many of the plants seen. Sightings included four species of heath, marsh gentians, round- and long-leaved sundew and two roe deer.
14 Oct.	Miss S. Garden. Hereford area. A riverside walk up the Wye from Hereford. Autumn colour beginning and the last summer flowers in evidence. After noon visit to Dinmore Manor garden.
4 Nov.	Miss R. C. Lee. Cotswold Edge. A glorious autumn day for the last meeting of the year. A woodland walk on the Cotswold escarpment to Uley, with views over the Severn Vale, then back over fields. Autumn colour still good.

RACHEL C. LEE, *Hon. Secretary, Field Committee.*

REPORT OF THE BOTANICAL SECTION, 1989

At the Annual General Meeting, held in the Schools Room of the Bristol City Museum and Art Gallery on 26 January 1989 the following were elected: President - Mr R. M. Payne; Hon. Secretary & Treasurer - Mr A. C. Titchen; Committee - Lady Rosemary FitzGerald, Miss I. F. Gravestock, Mr A. L. Grenfell, Mrs C. Kitchen, Mr M. A. R. Kitchen, Ms L. McDonnell, Dr N. Malcolm, Mr P. J. M. Nethercott, Miss A. P. Pockaon and Mrs N. Vaughan Davies

The following indoor meetings were held:

26 Jan.	Annual General Meeting & Members' Evening.
23 Mar.	"Wetland plants of the Gordano Valley", by Mrs Susan Wilson.
26 Oct.	"Weeds and Man", by Dr J. R. Ackroyd.

23 Nov.	Members' Evening, with transparencies.
28 Dec.	"In the steps of Linnaeus", by Mr Mark & Mrs Clare Kitchen.

The following field meetings took place, under the leadership of those shown:

12 Mar.	Dolebury Warren, Somerset, for bryophytes, Mr Peter Martin.
29 Apr.	Berrow Dunes, Dr N. Malcolm & Dr J. Rees.
14 May	Brean Down Rare Plant Survey, Lady Rosemary FitzGerald.
11 Jun.	Loxton Church and Purn Hill, Lady Rosemary FitzGerald & Mr Ian Taylor.
14 Jun.	Crook Peak, for *Koeleria valesiana,* Mr R. M. Payne.
25 Jun.	Cheddar Woods, Mr L. A. Cram.
5 Jul.	Rodney Stoke, Mrs Elizabeth McDonnell.
19 Jul.	Gordano Valley and Portbury, Mrs Helen Titchen.
30 Jul.	Plants and Trees of the Bishop's Palace, Wells, Miss I. F. Gravestock.
2 Aug.	Central Bristol walkabout, Mr A. L. Grenfell.
19 Aug.	Crook Peak and Compton Hill, Mr P. J. M. Nethercott.
10 Sep.	Selsey Common, Stroud, Mr Mark & Mrs Clare Kitchen.
17 Sep.	Weston Big Wood, Portishead, Mr J. G. Keylock.

TONY TITCHEN, *Hon. Secretary.*

REPORT OF THE GEOLOGICAL SECTION, 1989

At the Annual General Meeting held on 18 January 1989 the following were elected: President - Dr P. Hardy; Vice-President - Dr D. E. G. Briggs; Hon. Secretary/Acting Field Secretary - Dr P. R. Crowther; Hon. Treasurer - Mr D. A. Wilson; Committee - Mr S. Carpenter, Mr D. Cope, Mr M. Curtis, Mr V. Dennison, Mrs G. Hamilton, Mrs M. E. Poolman.

The following indoor meetings were held:

18 Jan.	Annual General Meeting & Presidential Address - "In search of the conodont animal", by Dr Derek E. G. Briggs.
15 Feb.	"Trilobites, evolution and the origin of species", by Dr Peter R. Sheldon (University of Wales College of Cardiff).
15 Mar.	"Lost worlds - vanished lives on the small screen", by Mr Neil Nightingale (BBC Natural History Unit).
18 Oct.	"Explosive vulcanism on Santorini, Greece", by Dr Timothy Druitt (University of Wales College of Cardiff).
22 Nov.	"Planetary geology and the legacy of Voyager", by Dr Robert M. Owens (National Museum of Wales)
13 Dec.	Members' Evening.

The following field meetings were held, under the leadership of those shown:

20 May	Hornsleasow Quarry, Gloucestershire, and Gloucester Museum, Mr Roger D. Vaughan and Mr David Dartnell (Gloucester Museum).
25 Jun.	William Smith localities, Professor Desmond T. Donovan.
30 Sep.	Middle Hope, Dr Peter Hardy.

PETER R. CROWTHER, *Hon. Secretary.*

REPORT OF THE ORNITHOLOGICAL SECTION, 1989

The following indoor meetings were held (that at Clifton College was particularly well attended, but overall there is an impression of some fall in attendance);

21 Jan.	Annual General Meeting & Presidential Address - "Win some, lose some: reflections on interactions between birds and others", by Mr S. M. Taylor.
2 Feb.	"Extremes of size." Films of Humming Birds and of the Bald Eagle, with discussion.
22 Mar.	"Owls in the Gordano Valley", by Mr R. M. Clarke, with a video film. Held in the Prep. School Hall, Clifton College.
13 Oct.	"Birds of Madagascar", by Mr A. Hawkins.
15 Nov.	"The breeding birds of Somerset", by Mr A. J. Parsons.
6 Dec.	"Archaeopteryx", by Dr J. Rayner.

Eighteen field meetings were held, including a winter cruise on the River Exe and summer visits to the East Devon Commons and the Quantock Hills. Three of the local walks were included in the "Walking in Avon" programme.

Members took part in the following surveys: the long-standing Birds of Estuaries Enquiry, National Wildfowl Counts and BTO's Nest Records Scheme; the River Severn Low Tide Survey (part of the Severn Barrage Enquiry), the BTO's National Breeding Bird Atlas project and Owl Survey, and the local Wintering Warblers and Birds in Gardens schemes.

TREVOR G. EVANS, *Hon. Secretary.*

LIBRARY REPORT, 1989

The post of Honorary Librarian has again been vacant during the year. Committee members have continued to carry out routine work in the Library and procedures have been improved. Our set of *Mammal Review* and some other volumes have been bound. The remaining holdings of foreign material, mainly journals, which had been in store on a University bookstack, have now been moved and listed. Most will be offered for sale as redundant to library needs. We record our gratitude to The University Librarian for storing these journals for us, a facility we no longer need to use. All the Society's library holdings are now housed in the Library Room. The Committee has drawn up guidelines for the loan of material to University departmental librarians, on application, for use by university staff and postgraduate students and this system has been put into operation.

The library opening hours of Wednesdays 1.15 - 1.45 pm and Saturdays 10.15 am - 12 noon have been maintained. In addition five Sunday openings were arranged, to try to encourage the use of the library; these were possible as the City Museum now opens on Sundays. During the year 213 visits were made by 37 members, who borrowed a total of 175 items. Visits by Museum and Art Gallery staff totalled 20. During the year 35 books and reports were purchased, including 15 Bristol University Avon Gorge Project reports. Currently 14 journals (including reports and other series) are received on subscription and 36 by exchange. Six books, 15 reports and 54 journals have been donated, for which we are indebted to Mr P. J. M. Nethercott, Mr D. A. Wilson, Mr R. G. Symes, Mr S. M. Taylor and Mr A. L. Grenfell.

We express the Society's gratitude to Mr M. Heighton (Director of Arts, Bristol City Council) and Mrs H. Woolley (Assistant Director of Arts, Museums and Art Gallery), for the continuing use of the Library Room during the year.

ANNE F. HOLLOWELL, *Chairman, Library Committee.*

OBITUARY: THOMAS EVERETT THOMPSON (1933 - 1990)

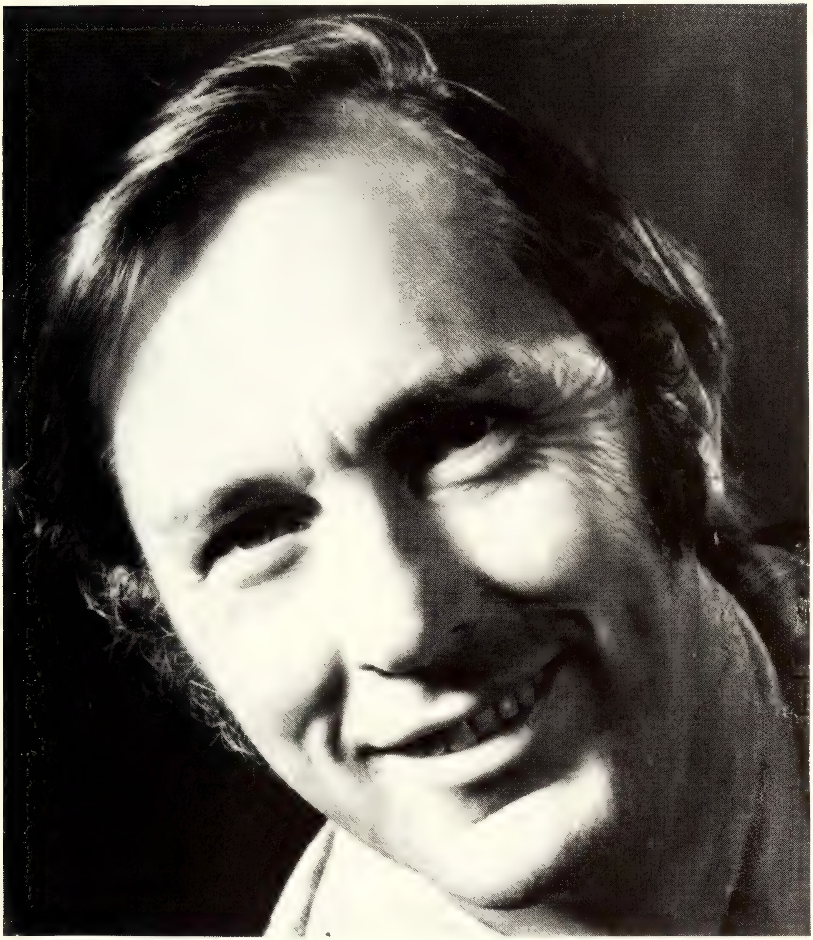
Dr T. E. Thompson, President of the Society for 1987 and 1988, was born at Doncaster, Yorkshire, on November 3rd 1933. He was tragically killed in a road accident on January 1st 1990.

Tom began his career as a research biologist and teacher after studying zoology at the University of Wales, Bangor, where he also completed his doctoral research. From the first he worked on nudibranch molluscs or "sea slugs", and these beautiful animals continued to be his main research interest for the next thirty years. He moved from Bangor to Port Erin in the Isle of Man, then to University College of South Wales and Monmouthshire, Cardiff, and finally in 1963 to the Zoology Department of Bristol University, where he remained for the rest of his distinguished career. He delighted in studying sea slugs and used his considerable talents to draw and photograph them so that others could both identify them and appreciate their fascination. His research brought him a DSc in 1964 and a Readership in 1973. It also took him to localities throughout the world, where he used his expertise in scuba diving to collect and study an immense variety of nudibranchs and other invertebrates.

Besides his interest in the taxonomy of nudibranchs, Tom had wide interests in invertebrate biology, particularly in factors regulating development and those involved in defence mechanisms. With these wide interests it was natural that he should take a very active part in the running of many societies, and he was at various times President of the Malacological Society of London, Fellow of the Zoological Society, Fellow of the Linnean Society of London, Vice-President of the Ray Society and a member of the Conchological Society, Porcupine and the British Society for Developmental Biology.

Tom joined the Bristol Naturalists' Society in 1975, and was elected to Council in 1979. His expertise and helpful approach soon made him a central figure in Council, and he was elected to the post of Honorary Editor in 1980. He was Editor for five years, during which time he was responsible for the modernisation of the *Proceedings*. For this the Society owes him an immense debt.

OBITUARY: DR T. E. THOMPSON



In 1987 he was elected President of the Society and for two years his friendly and persuasive leadership ensured the smooth running of Council. In this office he was particularly concerned that Council was kept up-to-date with the business of the Sections, and he attended many Section meetings to discover for himself how the different arms of the Society function. As an ex-Editor of the *Proceedings* he was proud to see the first of our "theme" issues appear while he was President.

As an ex-President Tom spent a great deal of time on the affairs of the Society, and continued a very active interest in the running of Council. His sudden death is a great loss to the Society. To his wife Denise and to his children the Society offers its sincere condolences.

COLIN LITTLE & ADRIAN L. GRENFELL

STATEMENT OF ACCOUNTS FOR THE YEAR ENDED 31 DECEMBER 1989

Income and Expenditure for the year

1988	Income	*1989*
3263	Members' subscriptions	3085
266	Income tax repayment	236
232	Donations	117
333	Sales of Proceedings and grants	2277
222	Sales of books and journals	111
–	General field meetings and Supper	279
96	Photographic competition	–
202	Bank interest	359
4614		6460

1988	Expenditure	*1989*
950	Printing and stationery	949
503	Postage and telephone	590
1979	Proceedings and Bird Report	1974
1250	Avon Gorge and Urban Ecology reprints	1250
141	Library, books	104
256	binding	189
191	subscriptions and journals	301
80	fire insurance	100
11	Donations	11
258	Indoor meetings	187
8	General field meetings & Supper (profit)	–
140	Grants to Sections	100
5767		5755
(1153)	Surplus (loss) on year	705
4614		6460

Balance Sheet at 31 December 1989

1988			*1989*
5000	Income Bonds (National Savings)		5000
935	National Savings Bank		609
696	Cash at bank – current accounts		1575
4289	– interest account		4648
20	Prepayment		20
10940			11852
3052	Less creditors (subscriptions in advance 551, Proceedings and reprints 2380, room hire 252, binding 189).		3372
7888			8480
	Represented by:		
206	Harry Savory Illustrations Fund		158
3	Conservation Appeal		33
5744	Hector Hockey Memorial Fund		5649
490	R.G. Williams Memorial Fund		490
1445	General Fund at 31 Dec. 1988	1445	
	Add surplus on year	705	2150
7888			8480

SPECIAL FUNDS

Receipts and Payments, year to 31 December

1988		*1989*
	Harry Savory Illustrations Fund	
206	Fund at 31 December 1988	206
	Donations to fund during 1989	27
	Less grant made in 1989	(75)
206		158
	Conservation Appeal	
3	Fund at 31 December 1988	3
	Donations to Appeal in 1989	30
3		33
	Hector Hockey Memorial Fund	
5744	Fund at 31 December 1988	5744
	Capital gain, stock redemption	32
	Year's investment income	588
	Less four grants made	(715)
5744		5649
	R.G. Williams Memorial Fund	
490	Fund at 31 December 1988	490
	Fund at 31 December 1989	490
490		490

NOTES TO THE ACCOUNTS

(1) No value is placed upon the contents of the Library and stocks of periodicals.

(2) These accounts do not record any balances held by sectional treasurers or the Ornithological Section's Special Fund of £534.

(3) The Hector Hockey Fund is represented by the Income Bonds and National Savings Bank.

P. J. M. NETHERCOTT

Hon. Treasurer
4 October 1989

T. B. SILCOCKS
Hon. Auditor
4 October 1989

Proceedings of the Bristol Naturalists' Society (1989), **49**: 14-18

AVON AND DISTRICT ENTOMOLOGICAL REPORT, 1989

by R. J. BARNETT

Natural History Section, City Museum and Art Gallery, Bristol BS8 1RL

INTRODUCTION

The Entomological Section has suffered recently from a lack of support from members of the Society. Meetings have been poorly attended and as a consequence the Section has, in effect, been suspended. This has come at a time when across the country a number of new entomology groups have been established (e.g. Oxfordshire Invertebrate Group, Leicestershire Entomology Society) and when there has been a rash of new text books covering moths, grasshoppers, hoverflies and so on. If the Section is to survive, it needs members' support. Do come along to meetings if you can - and if you know of anybody who is not a member, please recommend us.

Due to the decline of active membership, there are no reports this year covering the more noteworthy sightings of the different orders. Instead the following notes focus on one small group of beetles that has been the subject of attention by the Section in the past.

RECORDS OF LADYBIRDS IN THE BRISTOL REGION IN THE 1980s

The Coccinellidae family of beetles includes about forty-two species that are resident in the British Isles, twenty-four of which are generally known as ladybirds. Most people know the striking red and black of the Seven-spot Ladybird but there are others which are yellow and black and some which have many different colour varieties. The spring of 1990 has been notable for the large numbers of ladybirds to be found in our gardens and the countryside, giving rise to comparison with the phenomenal ladybird year of 1976. The fine summer of 1989, both preceded and followed by mild winters, has allowed more ladybirds than usual to survive their hibernation and also ensured a plentiful supply of their aphid prey.

There has perhaps never been so much interest in ladybirds as there is today. The National Biological Records Centre at Monk's Wood plans to publish an atlas of its records in the near future. Researchers at Cambridge University have also been compiling information on the current distribution and ecology of British ladybirds; they have been investigating the genetic factors which control the variation in colour and markings exhibited by such species as the Two-spot Ladybird. The "Cambridge Ladybird Survey" has been running since 1984 and, as a by-product, has generated an excellent guide to the identification and biology of these beetles (Majerus & Kearns, 1989). The national press and WATCH groups have run features on ladybirds, including an appeal for sightings of the Thirteen-spot Ladybird *Hippodamia 13-punctata*, last reported from Britain in 1950.

Locally the Entomological Section of the Bristol Naturalists' Society established a Ladybird Recording Scheme in 1976 (co-ordinated by Keith Miller) which produced numerous records for a decade before interest flagged in the late 1980s. Collation of these records and those of other entomologists who have recorded in the area has enabled the construction of the twenty-one distribution maps which accompany these notes (Figures 1A - 3I). They include records taken from the provisional distribution maps for Great Britain by the National BRC, Monk's Wood (Eversham, pers. comm.) and the Cambridge Ladybird Survey (Majerus, 1989).

The records cover the period 1980 - 1989 inclusive and are plotted by 10-km squares of the National Grid system. The area taken is that of Watsonian vice-counties 6 (North Somerset) and 34 (West Gloucestershire) (Dandy, 1989). This is the area covered by the Bristol/Avon Regional Environmental Records Centre (BRERC, based at the City Museum and Art Gallery), with the addition of the Forest of Dean.

The coarse recording unit used (10 km square) means that little can be deduced about local variations in the distribution of species. Undoubtedly those species with particular habitat requirements have been relatively poorly recorded. For example, the Water Ladybird is associated with stands of reed and reedmace, the large and impressive Eyed Ladybird with Scots Pine and the Hieroglyphic Ladybird with heathland. Care must be taken not to pass over the Larch Ladybird as its yellow colour may fool those expecting all ladybirds to be spotted. The predominantly black colour of the Kidney-spot, Pine and Heather Ladybirds requires a little practice if confusion with melanic forms of the Ten-spot and Two-spot Ladybirds is to be avoided.

The interesting Cream-streaked Ladybird was first reported from Suffolk in 1937. Since then it has expanded its range slowly across England and was found twice in East Gloucestershire in 1961 (Atty, 1983). I know of no other sightings in the Bristol region until it was reported to the Cambridge Ladybird Survey from North Somerset during the 1980s. However, the spring of 1990 has seen a number of reports from Bristol and it is intriguing to speculate whether it has been present but ignored for a few years, or whether it has only recently been able to colonise our area.

A specimen of the Adonis Ladybird *Adonis variegata* was reported from a vegetable stall in a supermarket at Henleaze, Bristol in 1987 but this has not been mapped as it presumably arrived by artificial means. This species may eventually be found to occur naturally here as it is known from the Midlands and South Wales.

Other species not seen locally during the 1980s include the Thirteen-spot, as previously mentioned, which may now be extinct in this country. The Five-spot *Coccinella 5-punctata* was considered to be restricted to parts of Wales and Scotland but has recently been recorded in the Midlands. The Scarce Seven-spot *C. magnifica* is mainly found in south-east England, where it is associated with Wood Ants *Formica rufa*. The Striped Ladybird *Myzia oblongoguttata* is a Scots Pine specialist which may perhaps yet be found here.

Distribution maps can reflect habitat and climatic influences upon ladybirds but they do not touch on such questions as changes in abundance from year to year or the relative frequencies of the colour forms of the more variable species. These sorts of problems can be investigated by taking a closer look at ladybirds on our favourite walks and even in the garden. They are a fascinating group to study: they can be identified easily without recourse to a microscope, they are beneficial to the gardener and farmer and they are a challenging subject for the natural history photographer. It would be nice to think that our *Proceedings* could carry a much more comprehensive survey of the ladybirds of the region in ten years' time.

ACKNOWLEDGEMENTS

I thank the following for providing me with ladybird records to add to those already held by the Bristol Naturalists' Society and the Bristol/Avon Regional Environmental Records Centre: K. Alexander, D. B. Atty; the National Biological Records Centre at Monk's Wood, A. Duff, R. M. Payne, A. Smith, Somerset Environmental Records Centre (A. Moon) and the Cambridge Ladybird Survey.

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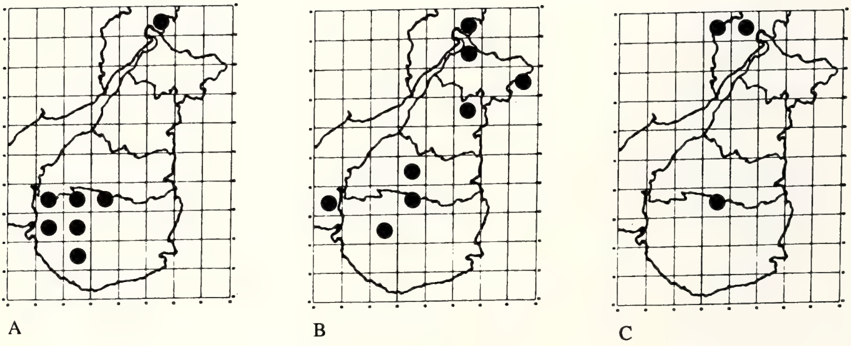

Figure 1. Distribution maps of Ladybirds in the Bristol region, 1980-1989. The maps here and in Figures 2 and 3 show the boundaries of of Avon and of the Vice-counties 6 and 34, and the 10-km squares of the National Grid. A, *Subcoccinella 24-punctata* (L.), the 24 Spot Ladybird; B, *Anisosticta 19-punctata* (L.), the Water Ladybird; C, *Aphidecta obliterata* (L.), the Larch Ladybird.

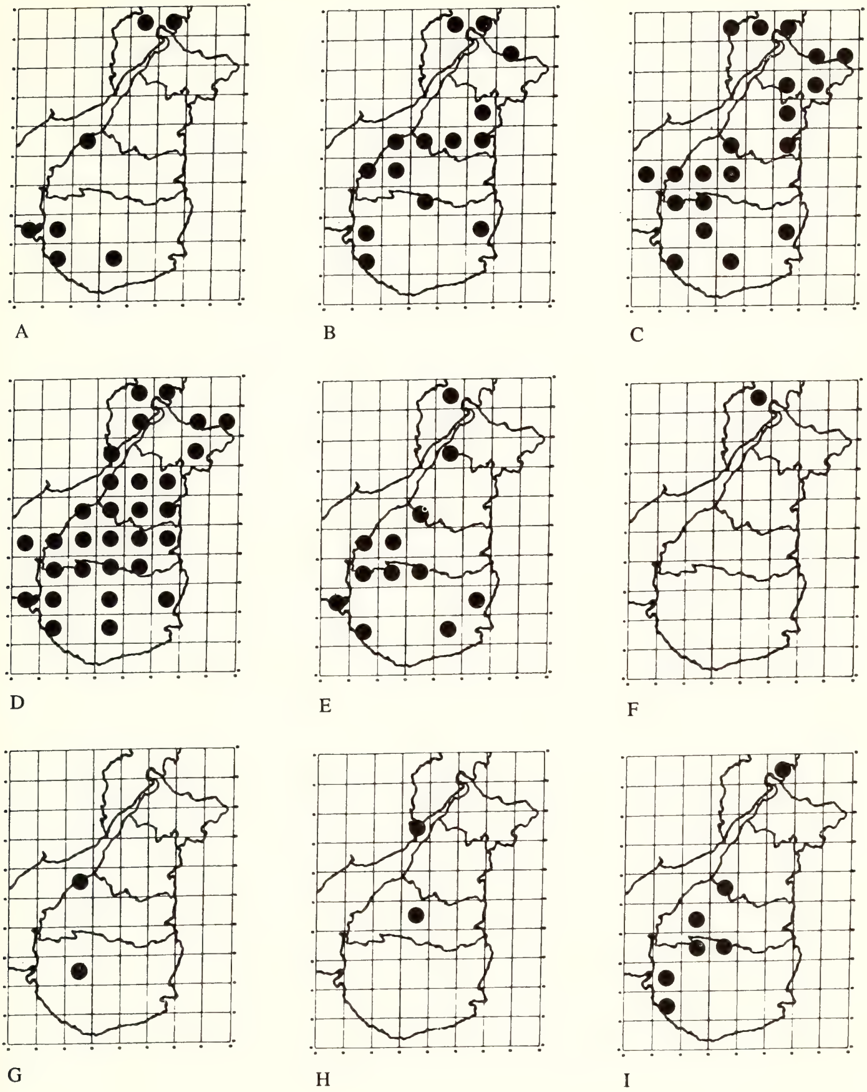

FIGURE 2. Distribution maps of Ladybirds in the Bristol region, 1980-1989. A, *Micraspis 16-punctata* (L.), the 16 Spot Ladybird; B, *Adalia 2-punctata* (L.), the 2 Spot Ladybird; C, *A. 10-punctata* (L.), the 10 Spot Ladybird; D, *Coccinella 7-punctata* (L.), the 7 Spot Ladybird; E, *C. 11-punctata* (L.), the 11 Spot Ladybird; F, *C. hieroglyphica* (L.), the Hieroglyphic Ladybird; G, *Halzia 16-guttata* (L,), the Orange Ladybird; H, *Myrrha 18-guttata* (L.), the 18 Spot Ladybird; I, *Psyllobora 22-punctata* (L.), the 22 Spot Ladybird.

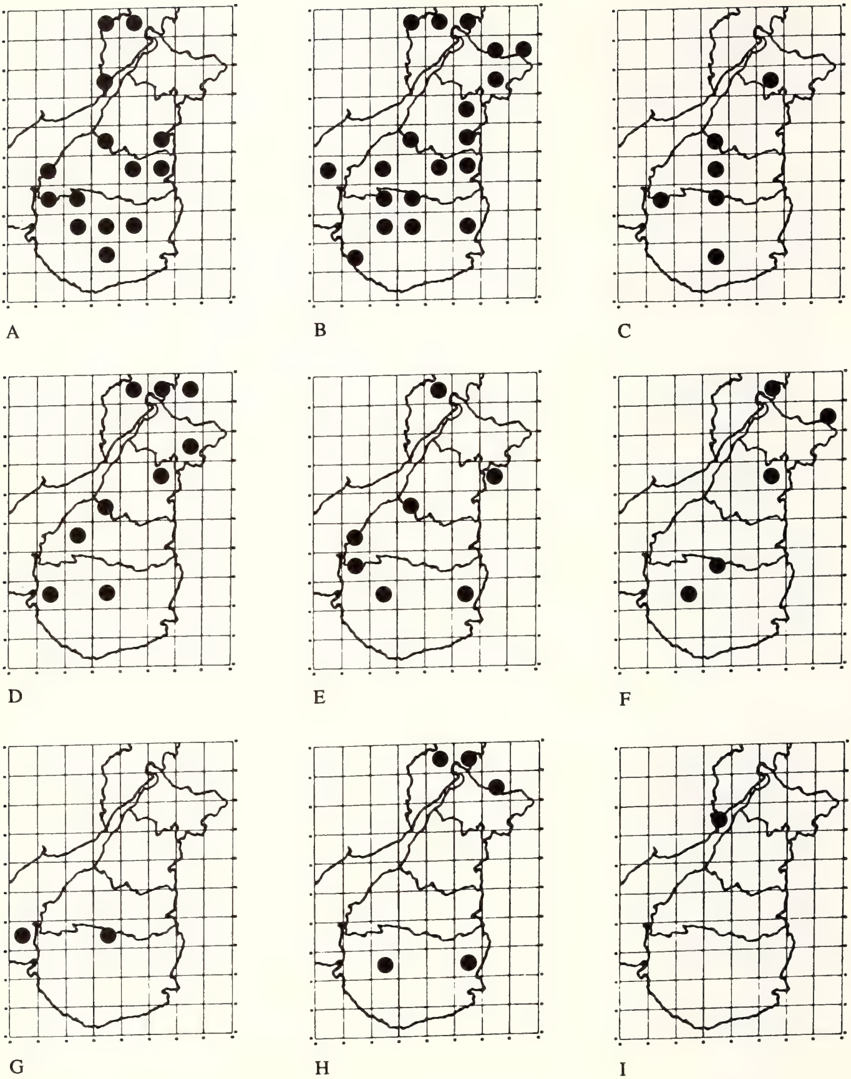

FIGURE 3. Distribution maps of Ladybirds in the Bristol Region, 1980-1989. A, *Calvia 14-guttata* (L.), the Cream-spot Ladybird; B, *Propylea 14-punctata* (L.), the 14 Spot Ladybird; C, *Anatis ocellata* (L.), the Eyed Ladybird; D, *Chilocorus renipustulatus* (Rossi), the Kidney-spot Ladybird; E, *Exochomus 4-pustulatus* (L.), the Pine Ladybird; F, *Coccidula rufa* (Herbst); G, *C. scutellata* (Herbst); H, *Rhizobius litura* (Fabr.), I, *Scymnus suturalis* Thunb.

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AVON MAMMAL REPORT, 1989

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INTRODUCTION

Soon after the publication of the last Avon Mammal Report, that for the year 1979 (Jayne, 1981), the Mammal Section of the Bristol Naturalists' Society was disbanded. The Section had been a strong group for many years since its inception in 1965, and whilst it no longer existed as a formal unit, interest in mammals in Avon did not diminish; indeed there was some pressure to resurrect both the Section and an Avon Mammal Report. Formal recording of mammals in Avon has been one of the aims of the Bristol/Avon Regional Environmental Records Centre (BRERC) based at the City Museum and Art Gallery, and some systematic records have been accumulated, but no formal reports have been produced.

In an attempt to stimulate interest further and to demonstrate the effort going into the study of mammals in Avon by both amateurs and professionals, and because the Wildlife and Storage Biology Discipline of ADAS has a considerable involvement with mammals, and needs such information, the authors undertook to produce an Avon Mammal Report for 1989. The ten-year break in recording effort prevented the systematic reporting of previous years, so it was decided to review the interest in mammals in Avon in 1989, the pressures on them, the problems they caused, and the studies and research in progress.

To this end we sought information from the many organisations and individuals known to be involved with mammals in any way in Avon. Letters were sent to conservation and animal welfare groups, to scientific workers, to pest control organisations, local authorities, hunts and others. The response was mixed but encouraging, despite a very tight deadline. We had stressed that one purpose of the Avon Mammal Report for 1989 would be to serve as a register of interest and involvement with mammals in Avon, and some replies were along those lines. Information is presented on a systematic basis where possible, and under other appropriate headings; some contributions have been reproduced largely as submitted, with minimal editorial input.

ORGANISATION OF MAMMAL INTEREST IN AVON

Since 1979 there have been significant changes in the organisation of involvement with mammals in Avon. From the conservation and study viewpoints, the Avon Badger Group and the Avon Bat Group have emerged with enthusiastic followings. The Avon Wildlife Trust, founded on 1 January 1980, clearly has an important role in encouraging conservation of mammals. Within the Ministry of Agriculture, Fisheries and Food (MAFF) the Regional Pests Service was retitled "Wildlife and Storage Biology" and given a new remit to include wildlife conservation on farmland amongst the advice it gave on the management of wildlife problems. The Nature Conservancy Council strengthened its local organisation with Species Protection Officers. The local authority pest control organisations have generally become revenue earning (on some aspects of their work at least) and welfare organisations and individuals have become skilled at handling and rehabilitating sick and injured mammals. National organisations such as the Mammal Society have become stronger; indeed, in 1989 the Mammal Society appointed a Conservation Officer, Dr Paul Bright, who is based in the Zoology Department of Bristol University. One of the projects undertaken by Dr Bright in 1989, and reported on in 1990, was a national compilation of the research work and other studies being undertaken by members of the Mammal Society (Mammal Society, 1990); reference is made to that publication regarding projects in or about Avon.

CHANGES IN LEGISLATION

Since 1979 there have also been significant changes in legislation affecting mammals. The Wildlife and Countryside Act 1981 was the major statute; it gave new protection to many species in general and, in particular, amended the Badgers Act 1973 and the Deer Act 1963. The Wildlife and Countryside (Amendment) Act 1985 further amended the Badgers Act by adding an anti-digging measure. The Wildlife and Countryside Act 1981 (Variation of Schedules) Order 1988 added the wild cat, dormouse, pine marten, the walrus, all whales, dolphins and porpoises to Schedule 5 (the "protected species" list). The Control of Pesticides Regulations 1986, made under the Food and Environment Act 1985, restricted the uses of pesticides to those listed as approved in *Pesticides 1989* (MAFF/HSE, 1989), and its predecessors and successors. Uses of any pesticides must, with a few exceptions, conform with the label on the product, and the label must have a MAFF or HSE registration number. This has affected especially the use of chemical repellents against mammals.

REPORTS ON MAMMALS

INSECTIVORA (hedgehogs and moles)

Hedgehog *Erinaceus europaeus*. Mammal Society (1990) lists a project for the Institute of Terrestrial Ecology, Monk's Wood, by R. Shore, M. Martin and D. Clarke, who were determining residue levels of heavy metals in road casualty hedgehogs from a polluted site at Avonmouth, and comparing them with a control site in north Cambridgeshire. They are seeking reports of road casualty hedgehogs in 1990-91.

Mrs Hilary Sperring from Portishead became expert in rehabilitation of hedgehogs, ranging in age from a few hours old to adults which were injured. All hedgehogs were weighed on arrival; litters were marked and kept separated from others to avoid any possibility of disease transmission. All feeding bottles and dishes were sterilised before use, the young being fed on goat's milk and colostrum. Most of the young hedgehogs, which started arriving at the beginning of June, were cold and hungry, and were put under a heat lamp to warm up before being fed. A major problem with later arrivals was the incidence of fly infestations, it being essential to remove eggs rapidly. This problem was described by Morris (1983) and, as he reported, many youngsters were found to be so badly affected that it was considered more humane to kill them.

Mrs Sperring reported that young hedgehogs received before September fared very well; the majority gained weight rapidly and, although they did not hibernate (perhaps due to the mild winter and perhaps to the amount of food fed to them), they lived outside in a greenhouse with boxes of hay and straw for warmth. Hedgehogs tend to mix their food, bedding and droppings together, and to sleep in that mixture, so their bedding needed regular changing. These animals were released into gardens after neighbours had been briefed on hazards to hedgehogs from pesticides.

Young hedgehogs which reached Mrs Sperring after the beginning of September did not prosper so well; they gained weight more slowly and, although rearing techniques were no different, they were affected by various diseases. A veterinary surgeon identified enterotoxaemia as the main cause of death, and no hedgehog infected with this disease survived. Another major cause for concern was pneumonia, which was often treated successfully. Young hedgehogs had often been given cow's milk by people trying to rear them, but this seemed to cause bloat and consequent death. Those with respiratory infections which reached Mrs Sperring early enough were saved.

Mole *Talpa europaea*. As in previous years, where moles were considered to be a problem in agricultural and horticultural situations especially, permits were issued by MAFF to allow the purchase of strychnine, to be used for poisoning of moles in deep runs (as described in ADAS Leaflet P318 *Control of moles*). The use of strychnine is permitted against moles only under the Animals (Cruel Poisons) Act 1963 and the recommended rate of use is 2g mixed with 100 worms, which should be enough to treat at least 4 hectares.

CHIROPTERA (bats)

The Avon Bat Group has been carrying out surveys and investigations in the county, and a review of the status of bats in the Avon District appeared in the 1988 *Proceedings* of this Society (Jones & Jayne, 1990). Dr Gareth Jones, a leader of the Avon Bat Group, was awarded a Royal Society University Research Fellowship to work at the University of Bristol on the ecology of echolocation in bats. He has supplied a systematic account of sightings and other records from Avon in 1989, based on observations by himself (GJ) and by David Clarke (DC), Angela Hollyfield (AMH), Jim Jayne (AFJ), Roy Hoddinott (RH), Diana Desmond (DD) and Bob Cropper (RC). A new advisory leaflet *Bats on farms* (ADAS, 1989) highlighted the reasons for declines in numbers of bats and the conservation measures which could be adopted on farms. A review of the effects on bats of remedial timber treatment chemicals (Mitchell-Jones *et al.*, 1989) reported that all species of bats found in Britain have declined in numbers, and all are classified as vulnerable or endangered.

Rabies in bats. Press coverage of rabies in bats raised some concern in 1989. The World Health Organisation's *Rabies Bulletin* (WHO, 1989) stated that bat rabies can be clearly separated from fox-mediated and dog-mediated types of rabies, and pointed out that there is no evidence yet of the bat virus type in terrestrial animals. Bat cases in Europe dropped from 140 cases in 1987 to 53 in 1988. Surveillance in the UK is described in the *Bulletin*; of the 350 bats submitted for testing in 1988, 10 were too decomposed for testing and all the rest were negative. Information on the bats of species examined from the UK has been included in the systematic account which follows.

Greater horseshoe bat *Rhinolophus ferrumequinum*. Avon Bat Group reports,"Maximum of 34 at spring 'feeding up' site. Bats arrived 28 March. One bat here had not been seen since 1970, and was at least 29 years old (GJ, DC). At most one bat used last year's nursery, now converted into accommodation. New record from Bourton Combe (DC), and major hibernacula found with up to 36 bats present in late autumn. Up to 8 found in hibernacula in north-west of county (GJ, AFJ, DC). Now recorded from 42 one-km squares in Avon." WHO (1989) reported bat rabies in this species in Turkey in 1956; two specimens examined in the UK in 1988 were negative. Mitchell-Jones *et al.* (1989) reported this species to be endangered, numbers having declined recently. Ransome (1989) reported on population changes in the Mendip Hills near Bristol, and near Stroud in Gloucestershire. His study, over a period of 26 years, involved visiting about 35 hibernacula about three times each winter. All numbers fell sharply to about half the original level between the winters of 1962-63 and 1966-67, stabilised, then rose in the late 1970s and early 1980s, and finally dropped in 1986 to about 30% of the 1962-63 level. Recapture data showed that juveniles born late in the summer are less likely to reach hibernacula than those born earlier. Dr Ransome's studies also showed that disturbance during ringing activities had no serious effects on bat population levels.

Lesser horseshoe bat *Rhinolophus hipposideros.* Avon Bat Group reports:- "Seen in usual hibernation sites. At least 74 at nursery site on 21 August (DC). Up to 15 in newly discovered hibernacula during autumn. Up to 9 in north-western hibernacula (GJ, DC). Two at Chew Stoke, ST5561, 5 in September (AFJ). The second nursery found in Avon was at Upper Langford, ST4559, where 45 bats present on 13 September (AFJ). Now recorded from 33 one-km squares in Avon." Mitchell-Jones *et al.* (1989) reported this species to be endangered, there having been recent declines in numbers.

Whiskered bat *Myotis mystacinus.* Avon Bat Group reports:- "Nursery colony at Compton Greenfield reached maximum of 37 before young born. At least 11 young born around 20 June; only 3 bats remained, 22 August (AMH). Male found injured at Frampton Cotterell, September (DD). Now recorded from 16 one-km squares in Avon." WHO (1989) reported that bat rabies had not been found in this species in Europe, and that 11 specimens examined in the UK in 1988 were negative. Mitchell-Jones *et al.* (1989) reported this species to be vulnerable, numbers having declined recently.

Natterer's bat *Myotis natteri.* Avon Bat Group reports:- "Two records: Barrow Gurney, ST5368 in April (RH), and High Street, Keynsham, ST6568 in September (AFJ). Now recorded from 19 one-km squares in Avon." WHO (1989) reported that no cases of bat rabies had been found in this species in Europe, and that 13 specimens examined in the UK in 1988 were negative. Mitchell-Jones *et al.* (1989) reported this species to be vulnerable, numbers having declined recently.

Daubenton's bat *Myotis daubentoni.* Avon Bat Group reports:- "Tree roost at Abbot's Pool still occupied during spring (DC, GJ). One hibernation record from Mendips (DC). Biddlecombe rift, 26 March (RC). Now recorded from 18 one-km squares in Avon." WHO (1989) reported that bat rabies had been found in three bats of this species in Germany and Denmark between 1983 and 1988, but four specimens examined in the UK in 1988 were negative. Mitchell-Jones *et al.* (1989) reported this species to be vulnerable, there being no information on recent changes in populations.

Vagrant species ? *Myotis muricola.* Avon Bat Group reports:- "A bat found dead on a tanker at Avonmouth on 9 August 1988 (DC) was identified by J.E. Hill of BM(NH) as probably *Myotis muricola*. The ship had come from Malaysia or the Philipine Islands. The bat is closely related to our whiskered bat."

Serotine *Eptesicus serotinus.* Avon Bat Group reports:- " One bat at Clapton during late summer (DC). The nursery roost at Blagdon is still occupied (DC). Bat detector record from Downend, ST6578, 16 June (AFJ). Now recorded from 14 one-km squares in Avon." WHO (1989) reported bat rabies in serotines in Germany, USSR, Poland, Denmark and the Netherlands, particularly since 1983, with the earliest record from Germany in 1963. There were 160 positive in Denmark and 126 in the Netherlands. Sixteen specimens examined in the UK in 1988 were negative. Mitchell-Jones *et al.* (1989) reported this species to be vulnerable and declining in numbers.

Leisler's bat *Nyctalus leisleri.* Avon Bat Group reports :- "Three records for the year; one from Clifton (Mortimer Road) 6 Feb., and a young male from Cotham Vale 18 August (GJ, AMH). A young female at St Ursula's School, Henleaze 13 September (DC). Total number of records for Avon since 1948 is now nine." WHO (1989) reported that one specimen was examined in the UK for bat rabies in 1988 and was negative. Mitchell-Jones *et al.* (1989) reported Leisler's bat to be rare.

Noctule *Nyctalus noctula.* Avon Bat Group reports :- "The roost site at Willsbridge was apparently unoccupied this year (AFJ). Bat detector records only during 1989 included Downend ST6578 in August, Bishop Sutton ST6060 in August (AFJ) and Chew Valley Lake ST5758 (DC). Now recorded from 34 one-km squares in Avon." WHO (1989) reported the finding of bat rabies in three specimens in 1954 in Yugoslavia; eight specimens examined in the UK in 1988 were negative. Mitchell-Jones *et al.* (1989) reported this species to be vulnerable and declining in numbers.

Pipistrelle *Pipistrellus pipistrellus.* Avon Bat Group reports:- "Winter records from Brislington ST6171 on 1 Feb. (AFJ) and ST6170 on 16 Nov. (GJ), also three females hibernating in a roof at Long Ashton ST5269 on 23 Nov. Other records: Hartcliffe ST5868 April (AFJ), Failand ST5271 22 May (AFJ), one in central Bath ST7565 3 July (AFJ), female with young Winterbourne ST6580 25 June (AFJ), female with young Hartcliffe ST5867 10 July (AFJ), one caught by cat at Clevedon ST4170 8 August (AFJ), two bodies found at Nailsea ST4670 10 August (AFJ), one found entangled in fishing tackle Tortworth ST6992 27 August (AFJ), Patchway ST5928 29 August (AFJ), Lower Failand ST5173 1 September (AFJ), Avonmouth Docks ST5078 3 November (DC). Bat detector records from Compton Greenfield (GJ) and from Downend ST6578 16 June (AFJ). Approximately 30 in a house near Dundry ST5467 (AFJ). Nursery roosts also at Butcombe 7 July, Coalpit Heath ST6781 3 August, and 200+ at Saltford 3 August. Colony of 200+ Bitton August (AFJ). Roost in block of flats, Weston-s-Mare ST3358 13 September (AFJ). Now recorded from 145 one-km squares in Avon, with 64 summer colonies found." WHO (1989) reported bat rabies in two specimens in Germany between 1983 and 1988, but 233 specimens examined in the UK in 1988 were negative. Mitchell-Jones *et al.* (1989) reported the species to be vulnerable and declining.

Brown long-eared bat *Plecotus auritus.* Avon Bat Group reported:- "One hibernation record from Mendips (DC). Two records from northern Bristol at Henbury ST5579 and Sneyd Park ST5575 (GJ, DC). Marshfield ST7773 30 March, approximately eight at Camerton ST6858 7 July, Yate ST7083 3 August, found dead near Thornbury ST6293 5 August, High Littleton ST6458 5 September, injured at Bishop Sutton ST6061 on 29 October (all records AFJ). 27 colonies now known in Avon, and recorded from 53 one-km squares." R. W. Howard reported work on a colony of long-eared bats at Keynsham that has remained remarkably constant for 20 years. Young were born early in 1989. He was attempting to determine the extent to which this species uses echo-location when commuting and when foraging, and was trying to find where the bats go in winter, and where the adult males go in summer. He felt that in 1989 he had made a good start towards answering the questions on use of echo-location. WHO (1989) reported that bat rabies has not been found in Europe in this species; 53 specimens examined in the UK in 1988 were negative. Mitchell-Jones *et al.* (1989) reported this species to be vulnerable and declining in numbers.

Bat projects Other research projects on bats which have a relationship to Avon (Mammal Society, 1990) included: studies by G. Jones and others in the Department of Zoology at Bristol University, on the relationship between flight morphology, foraging strategy and echo-location; and by S. Maunde and D. Bullock at Leicester who were compiling the National Bat Sites Database for all underground roosts. The Victoria Street Animal Sanctuary had handled pipistrelle and whiskered bats during 1989; their knowledge and experience with bats increased considerably during the year. The Nature Conservancy Council, ADAS Wildlife and Storage Biology Discipline, and Bristol City Council's Parks Department were all involved with bats in Avon during 1989.

CARNIVORA (carnivores)

Fox *Vulpes vulpes.* Victoria Street Animal Sanctuary reported that foxes were amongst the species which they had helped to rehabilitate after injury. Research work reported to be in progress in Avon by the Department of Zoology at Bristol University (Mammal Society, 1990) was concerned with combating rabies, and included strategies for distributing bait to foxes and badgers, the effects of social factors on dispersal of urban foxes, and contact rates and social behaviour of urban foxes in relation to the transmission of rabies. One effect of the Control of Pesticides Regulations was that it became illegal to use cyanide gassing powders to gas foxes in their earths, as the compounds had not been approved for that use under those Regulations.

Ferret *Mustela putorius furo.* A nationwide survey recording distribution of feral ferret colonies, started in 1987, was being conducted by C. Owen (Mammal Society, 1990), but no information was available for Avon.

American mink *Mustela vison.* A review of the damage caused by mink, and methods of prevention, was presented by Harrison & Symes (1989). The type of damage notified most frequently in the south-west of England was to domestic hens and ducks. Reports of mink damage were most frequent in the spring and late summer. The requirement for occupiers of land to report the presence of mink was removed by the Mink (Keeping) Order 1987.

Badger *Meles meles.* Badgers, as ever, attracted considerable attention in Avon in 1989. The Avon Badger Group supplied a copy of their 1989 report. They felt that the number of incidents and enquiries with which they were involved justified their existence. They had saved a sett by securing modifications to plans for a new car park, were represented at a planning appeal for Winscombe Station Site and were trying to save badgers whose sett was on the route of the Bristol Ring Road at Shortwood. However, they had not persuaded Avon County Council's Highways Department to erect a danger sign on the Warminster road, nor to try mirrors to deflect badgers. Pressure for part of the M5 to be fenced to prevent badgers crossing had also failed. They established a sett database at BRERC and collected records on road casualties, of which there had been many in the Weston-super-Mare area. Drought during 1989 led to cubs dying or not thriving.

Nick Goff, Deputy Curator of Woodspring Museum, reported involvement with mapping of badger setts in Weston Woods. Avon Wildlife Trust reported that they had provided badger gates along an area of newly erected stock-proof fence at their reserve at Dolebury Warren, and that there were encouraging signs of their use by badgers. A map of the badger sett distribution in Somerset in 1988 (Neal, 1989) included figures for the Mendips, part of which is in Avon; badgers were reported to be very common in the south-facing slopes of the Mendips, particularly in the combes.

Penny Cresswell and Stephen Harris of the Department of Zoology at Bristol University and others (Cresswell *et al.*, 1989) reported on the results of a national survey of pre-selected one-km squares in which the distribution and status of badgers, and information on their current persecution, was recorded. The data collected was intended to act as a baseline for future surveys. They estimated that there are currently some 43,000 social groups of badgers in Britain. They found that badger digging can be a problem and, where it is common, can have a significant local effect on badger numbers. They also examined one-km squares in which MAFF badger/bovine tuberculosis control operations had been carried out since 1975. They could not demonstrate a significant reduction in badger activity in the controlled squares, but did find an increased number of subsidiary setts which may be due to disruption of social and territorial behaviour following a control operation.

The 13th Report by MAFF on *Bovine tuberculosis in badgers* (MAFF, 1989) reported that in 1988, as part of the research work into a live diagnostic test for TB in badgers, 177 live badgers were transported successfully from breakdown premises in Avon, Gloucestershire and Dorset to MAFF's Central Veterinary Laboratory. The prevalence of disease in these animals was reported to be 39.5%, was higher in cubs than adults and was lowest in a small sample of yearlings. The report suggested that there may be a significant level of cub mortality due to tuberculosis.

Operational work on bovine tuberculosis in badgers by the State Veterinary Service of MAFF now follows the recommendations of the Dunnet Report (Dunnet *et al.*, 1986) and is restricted to the breakdown farm. The 14th Report (MAFF, 1990) stated that in 1989 there was little change in the number of outbreaks in the traditional problem area of the Cotswolds (Gloucestershire and Avon). The origin of all nine new herd infections in Avon was attributed to badgers. Six outbreaks were confirmed in the St Catherine's valley near Bath, with single cases at Hawkesbury Common, Wotton-under-Edge and Farrington Gurney. In 1988 (MAFF, 1989) single outbreaks attributed to badgers occurred in the parishes of Yate and Marshfield, which were areas previously free from bovine tuberculosis. Seventeen "problem" parishes in the county of Avon were listed in the 14th Report as having a recent history of cattle herds with tuberculosis breakdowns of badger origin in 1989. Most of those parishes were in the Bath/Cotswolds area, exceptions being the parishes of Wraxall and Tickenham in the Woodspring District of Avon. The 14th Report included a useful map of all such "problem" parishes in south-west England.

A summary of MAFF badger removal operations in Avon since 1975 listed 38 authorised between August 1975 and March 1986, i.e. "pre-Dunnet" (but excluding operations in the Thornbury Experimental Area up to 1981), 12 authorised "post-Dunnet" between April 1986 and December 1988, and 10 authorised in 1989, none of which was extant at the end of 1989. Between 1972 and 1988, 890 badger carcasses from Avon had been submitted to MAFF by the public, of which 70 were positive for *Mycobacterium bovis*, the causal organism of bovine tuberculosis. In 1989, 112 carcasses were submitted; five were positive. Out of 843 badgers from Avon killed by the Ministry between 1974 and 1987, 122 were found to be infected; the figures for 1988 and 1989 were 38 infected out of 110 and 35 out of 129 respectively.

The 14th Report summarised recent work in the Thornbury area, comparing the results of a survey of 10,000 hectares in 1989 with those from 1975. Badger control in the area ceased in 1981 when it was reported to be free of badgers. The 1989 survey showed that badgers had recolonised the whole of the Thornbury area, although the population was less than the expected full carrying capacity, the number of active setts being approximately half the 1975 figure.

Separately in MAFF, the Wildlife and Storage Biology Discipline of ADAS continued its advisory and statutory role on problems caused by badgers. The nature of these problems and some of the solutions offered was discussed by Symes (1989). WSB gave more advice on badger problems than on those caused by any other species.

Otter *Lutra lutra*. Jefferies (1989) reported on the use of body weights of otters to measure stress or over-exploitation and analysed data from 1,286 otters over a period of 160 years. He considered that the 1977-1979 picture, of otters present in only 6% of sites visited in England (by a Bristol Naturalists' Society member, the late Libby Lenton) was likely to represent the trough of the decline. The National Otter Survey was repeated in 1984-1986 and showed a modest improvement in western areas of England. Jefferies believed that if water quality could be improved and maintained the otter would again inhabit much of southern Britain.

LAGOMORPHA (rabbits and hares)

Brown hare *Lepus capensis*. S. Wray and S. Harris of Bristol University were studying the ecology and management of hares in a commercial coniferous forest (Mammal Society, 1990).

Rabbit *Oryctolagus cuniculus*. Ross *et al.* (1989) reported from a study including a site in southern England that myxomatosis in farmland rabbit populations showed a clear two-peaked annual cycle, with a main autumn peak between August and January and a subsidiary spring peak between February and April. They considered that, whilst the effects of myxomatosis were much less than during the 1950s and 1960s, it continued to be an important mortality factor and may still have a regulatory effect, with autumn-winter peaks of disease reducing numbers present at the start of the breeding season.

RODENTIA (rodents)

Red squirrel *Sciurus vulgaris*. The Forestry Commission's Forest District Manager at Marlborough, Mr R. C. Budden, supplied the results of the 1988 survey of Commission forests for the presence of red squirrels. This showed that the locations nearest to Avon for red squirrels on Forestry Commission land were in the Isle of Wight, Mid Wales and parts of Norfolk and Suffolk.

Grey squirrel *Sciurus carolinensis*. The Forestry Commission reported that grey squirrel numbers in their forests in 1989 were similar to those in recent years. Mr R. C. Budden supplied the results of the 1988 survey of Commission forests for the presence of grey squirrels; seven forests in the west of England reported the presence of grey squirrels only. The Commission remained concerned at the damage which grey squirrels may cause to trees. In some parts of the south-west squirrel control clubs have been formed by growers seeking to limit such damage. Woodspring District Council's Environmental Health Department reported that they had received numerous complaints of squirrels in roof spaces in the spring of 1989.

Dormouse *Muscardinus avellanarius*. Avon Wildlife Trust were attempting to increase dormouse populations throughout their reserve at Goblin Combe by providing dormouse boxes. Dr P. Bright (Mammal Society's Conservation Officer) was involved in several dormouse projects, including: assessing the minimum size of wood that could support a viable dormouse population; dispersal of dormice; and, with Dr P. Morris, population dynamics of dormice in different habitats (Mammal Society, 1990). Dr Bright provided field training on dormice to groups in Avon, and with Dr Morris co-published a useful guide to dormouse conservation (Bright & Morris, 1989).

House mouse *Mus domesticus*. Mr H. R. Nowell (Principal Environmental Health Officer, Bath City Council) reported that complaints of house mouse infestations for the years 1985-86, 1986-87, 1987-88 and 1988-89 were 241, 222, 218 and 328 respectively. He expected the 1989-90 figures to be similar. Mr Richard Bevan (Manager, Pest Control Services, Bristol City Council) reported that in the period April 1988 to March 1989 there were 1,255 notifications of house mouse infestations, an increase of 21% over the previous year's total of 1,039.

Black rat *Rattus rattus*. The Mammal Society was conducting an enquiry into the status of the black rat. The species is probably extinct in Avon.

Common rat *Rattus norvegicus*. Woodspring District Council's Environmental Health Department reported that a high population of rats, evident since the winter of 1988-89, was continuing. Young rats were sighted in January 1990. Mr H. R. Nowell (Principal Environmental Health Officer, Bath City Council) believed that an increase in the number of complaints about rat infestations, from 242 in 1987-88 to 328 in 1988-89 was likely to be reflected in the 1989-90 figures also. He considered that the increase in the rat population was due to the recent mild winters. His figures for rat complaints for 1985-86 were 374 and for 1986-87 were 287. Mr Richard Bevan (Manager of Pest Control Services, Bristol City Council) reported that as a result of extensive publicity about the growing rat problem the funding for rat control in sewers for 1988-89 was increased from £20,000 to £26,000, and for 1989-90 to £60,000. A change in poisoning technique in sewers was reported with the introduction of the use of sachets of brodifacoum, a second generation anticoagulant rodenticide. The numbers of rat problems in premises notified in the period April 1988 to March 1989 were 1,658, compared with 1,597 in the previous year. The Bristol City Docks Water Study Group had again stressed the need for continuing monitoring of the rat situation, particularly with the increased recreational use of the docks and the concern over the incidence of Weil's disease.

Water vole *Arvicola terrestris*. The results of an enquiry into the status of the water vole in Britain, based on data from County Mammal Reports and other sources, were published by Jefferies, Morris & Mulleneux (1989). The aim was to provide the basis for a conservation plan and for future monitoring. There were indications of a long-term decline during this century, possibly due to adverse habitat changes; pollution of rivers and the spread of the introduced American mink were considered to have exacerbated the situation. All sources agreed that predation by mink was the most important single threat to water voles. Information for Avon was included in a south-west England total, indicating that 0·32% of the 10-km squares in the region were occupied by water voles, and giving an index figure of 0·66 water vole localities per 10-km square. The highest index numbers were 5·03 and 2·03 for the east Midlands and the south of England respectively. There is clearly a case for more work on this species in Avon.

SMALL MAMMALS

Wildlife and Storage Biology entered into the seventh year of ADAS's 'National Small Mammals in Hedgerows Survey' at a site on the Avon/Gloucestershire boundary. Spring and autumn trapping sessions using Longworth traps were carried out in a species-rich hedgerow. Species caught in the spring in 796 trap-nights (with 1988 figures in brackets) were: wood mouse *Apodemus sylvaticus*, 3 (20); bank vole *Clethrionomys glareolus*, 10 (16); and common shrew *Sorex araneus*, 9 (7). The autumn catches, again in 796 trap-nights, were: wood mouse, 29 (45); bank vole, 15 (8); common shrew, 16 (4); pygmy shrew *Sorex minutus*, 7 (0); and field vole *Microtus agrestis*, 1 (0). A water shrew *Neomys fodiens* was captured in 1988 but not in 1989. Wood mice continued to show dramatic seasonal variation in numbers: low in spring and high in autumn. Trap mortality was very low, with only two common shrews dying in traps. See paper herein by Trump (1991).

CETACEA (whales and dolphins)

Mammal Society (1990) listed "P. G. H. Evans and 800 observers" involved in a national sightings scheme for determining distribution and status of whales and dolphins in British waters.

PEST CONTROL

British Telecom's *Yellow Pages* listed 17 private pest control companies operating in Avon, with most offering services in the control of rats, mice and moles. Local authority pest control departments concentrated mainly on rats and mice (some on squirrels also).

WELFARE AND REHABILITATION

The Victoria Street Animal Sanctuary at Staple Hill, run by Diana and Tyrone Desmond, saw a vast increase in 1989 in the numbers of wildlife casualties taken to them. Most were birds, but they did also handle two bat species, fox, grey squirrel and wood mouse, and reptiles and amphibians. Many of their casualties came from the RSPCA, Avon Wildlife Trust and from veterinary surgeons; they were willing to help other groups or individuals also. They expressed concern that when creating urban wildlife reserves consideration must be given to the inevitable increase in mammal and bird casualties which will follow.

MAMMAL CONSERVATION

Antony Merritt (Conservation Officer, Avon Wildlife Trust) reported that AWT were particularly involved with management and conservation of mammal populations on their Goblin Combe and Dolebury Warren reserves. Sophie Price (Conservation Officer, Bristol City Council's Parks Department) was involved with the implications of planning applications or development proposals on species such as badgers and bats especially. Nick Goff (Woodspring Museum) reported that he is regularly contacted by the public for information, including about the conservation of mammals. Wildlife and Storage Biology also gave advice on mammal conservation, particularly with regard to protected species on farmland.

ACKNOWLEDGEMENTS

Grateful thanks are due to the following individuals and organisations for contributing to this report and for registering their involvement with British wild mammals in Avon:- Avon Badger Group (Caroline Collett), Avon Bat Group (Gareth Jones), Avon Wildlife Trust (Antony Merritt), Bath City Council (H. R. Nowell), Bristol City Council's Parks Department (Sophie Price) and Pest Control Department (Richard Bevan), the Department of the Environment's Wildlife Division (Graham Wilcox), the Forestry Commission (R. C. Budden), Hilary Sperring, the Nature Conservancy Council (Richard Bradford), R. W. Howard, Victoria Street Animal Sanctuary (Diana and Tyrone Desmond), Woodspring District Council (Neil Pollard) and Woodspring Museum (Nick Goff).

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BRISTOL BOTANY IN 1989

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The year 1989 was exceptional for its extremely mild weather during the winter months, both at the beginning and end of the year, and for its very dry and sunny summer. The beginning of the year was the mildest on record, with temperatures reaching some 2·5°C higher than normal (2·2°C above average for the period January to March). May and July were both marked by high temperatures (averages for both months were some 2°C above normal) in a summer with substantially above-average hours of sunshine. Although the rainfall for the year at Long Ashton Research Station (to which all meteorological records relate) was not far below the average figure (866·8mm, 99% of average), the five months from May to September were much drier than usual, totalling 204·3mm of rain, less than one-quarter of that for the whole year.

With the very mild winter, by New Year's Day *Helleborus foetidus* was flowering on Churchill Batch, and in Harptree Combe single plants of *Ranunculus ficaria* and *Lamium album* were in bloom. In Cheddar Wood *Daphne laureola* was well in flower, and there were a few blooms of *Primula vulgaris*. At Charterhouse, *Hornungia petraea* was in flower and fruit by mid January, Snowdrops were appearing and *Helleborus viridis* was flowering at Nettlebridge and at Winterhead Farm, S (all records RSC). In the summer, the effects of droughting were very evident, flowering of many species being cut short and some annuals failing to appear. However, the hot dry summer benefited some species, notably *Cyperus fuscus* at Gordano.

The National Trust's policy of clearing parts of the Cheddar Gorge from overgrown woodland and scrub has continued and the *Sorbi* are being protected. Dr M. C. F. Proctor and his collaborators are now making a study of *Sorbus* populations by means of the variation of peroxidase isoenzymes in stem tissues; this approach gives critical identification of individuals and information on the genetic variability of populations (see Proctor, M. C. F. *et al., New Phytologist,* 1989, Vol. 112, pp. 569-575). These studies are being extended to several taxa in the Bristol area, including *Sorbus porrigentiformis* at Cheddar, Leigh Woods and Wick Rocks. In Leigh Woods, besides one, more widespread, form of *S. porrigentiformis* there is also another form (a planted specimen of which has been grown in the Cambridge University Botanic Garden) which differs in some features of the leaves and fruits (PJMN). Peroxidase isoenzyme studies have now shown the latter form to differ from *S. porrigentiformis* from sites in Devon and elsewhere as well as Leigh Woods. Further field and isoenzyme studies will help to elucidate the nature of these microspecies as well as forms of *S. eminens*. The *Sorbus* from Leigh Woods formerly referred to as *S. devoniensis* 'Theophrasta' is now described (*Watsonia,* 1989, Vol. 17 (Part 4), pp. 392-395) as a new species, *S. croceocarpa* P. D. Sell. The paper deals with the *Sorbus latifolia* (Lam.) Pers. aggregate in the British Isles.

Since the first publication, in 1983, of the University of Bristol Avon Gorge Project (funded by The Arnold Foundation and other bodies, and organized by Dr L. C. Frost) there have been fourteen further publications up to the end of 1989. They cover a range of topics concerning the flora of the Avon Gorge and particularly its management. Historical aspects of land use are also covered. Populations of rare plants are assessed in some detail and recommendations made with regard to conservation. Some papers relate to particular species, notably *Veronica spicata* (Project No. 8, 1986, by L. Houston) and *Tilia cordata* (Project No. 11, 1988, by S.D. Micklewright). Management prescriptions are formulated for a range of habitats in Leigh Woods and also for Clifton and Durdham Downs. The most recent publication (No. 15, December 1989, by Dr C. M. Lovatt), which, like many of the others, is well illustrated, concerns the dwarf sedge grasslands of the Gorge and deals very fully with *Carex humilis*.

A biography of William Turner, born about 1510 and at one time Dean of Wells (see J. W. White's *Flora of Bristol,* 1912, pp. 46-48), was published by Routledge in 1988. The book, entitled *William Turner Tudor Naturalist Physician and Divine,* is written by Whitney R. D. Jones. Although one chapter assesses Turner as a naturalist, most of the book is concerned with his standing as a physician and his involvement with the religious controversies of his time. There is no specific mention of Turner's botanical activities in the Bristol and Wells area. His well-known *Herbal* provides the first descriptions of many plants of the British flora, including *Trinia glauca* which he reported (1562) from 'Saynt Vincentis rock a little from Bristow'.

A substantial number of records have been made this year, filling gaps in our knowledge of the distribution of many plants. The grass *Gastridium ventricosum* is proving to be more widespread than previously thought. A notable occurrence is of *Polygonum oxyspermum,* very rare in v.c. 6, in Sand Bay. The yield of aliens from Avonmouth Docks in 1989 was thin, but *Malope trifida* (Malvaceae) was found new to the Bristol area in a section of new roadwork near Downend. For several decades, few records of charophytes of the Bristol area have been made; a detailed study of these stoneworts in the Gordano valley has strengthened our knowledge of their distribution and provided records of several uncommon taxa.

The death on 26 June 1989 of Mrs Joan Appleyard has meant the loss of a first-rate bryologist. For many years she was a referee of the British Bryological Society for hypnaceous mosses. It is fitting that her name should be commemorated in *Brachythecium appleyardiae* S. V. McAdam & A. J. E. Smith (*Journal of Bryology,* 1981, Vol. 11 (Part 4), pp. 591-598), first found (1967) by her in Harptree Combe, S. Her paper on the liverworts and mosses of Somerset (A Bryophyte Flora of North Somerset, *Transactions of the British Bryological Society,* 1970, Vol. 6, pp. 1-40) is a major and authoritative contribution. She made many interesting records of bryophytes herself in the county, operating from her homes in Shepton Mallet, Wells and finally West Horrington. Her numerous first records for Somerset include the hepatics *Riccia warnstorfii, Marsupella emarginata* and *Cephaloziella hampeana*, and the mosses *Pohlia lutescens, Fissidens exiguus, Amblystegiella sprucei* and *Isopterygium seligeri*. She also contributed records of flowering plants, right up to the time that she entered a nursing home in 1989. She will be sadly missed not only locally but also nationally.

The area covered by this report is essentially that defined by J. W. White for his *Flora of Bristol* (1912), with the addition of that part of the old county of Gloucestershire lying between the eastern boundary of White's area and the Wiltshire border. It comprises the northern part of the Watsonian vice-county of North Somerset (v.c. 6) and the southern part of West Gloucestershire (v.c. 34). In the following list these parts are designated S and G respectively.

Names of contributors associated with several records, or with the determination of specimens, are abbreviated as shown opposite.

BRISTOL BOTANY IN 1989

CJC	C. J. Connell	CK	Mrs C. Kitchen
RSC	R. S. Cropper	MARK	M. A. R. Kitchen
GC	Miss G. Crouch	ACL	Dr A. C. Leslie
JF	Mrs J. Fryer	EJM	Mrs E. J. McDonnell
IFG	Miss I. F. Gravestock	PJMN	P. J. M. Nethercott
DG	D. Green	AN	A. Newton
IG	I. Green	RMP	R.M. Payne
PG	P. Green	APP	Miss A. P. Pockson
ALG	A. L. Grenfell	RDR	R. D. Randall
RH	R. Higgins	NFS	N. F. Stewart
RAJ	R.A. Janes	SW	Mrs S. Wilson

Asplenium adiantum-nigrum L. A small colony on rock exposure near the River Avon, at the Horse Shoe Bend, between Sea Mills and Shirehampton, G, PJMN. Also at Batheaston, S, RSC.

Dryopteris carthusiana (Villar) H.P. Fuchs Westhay Moor and Sharpham Moor, S, RSC.

Botrychium lunaria (L.) Sw. In 1987, Goblin Combe, Mendip, S, RH.

Ranunculus circinatus Sibth. In two places, Tealham Moor, S, RSC. Also *Veronica catenata* Pennell.

Nymphaea alba L. Pond in dune system, Berrow, S, RSC.

Nuphar lutea (L.) Sm. With *Sparganium emersum* Rehmann, Freshford, S, RSC.

Cochlearia danica L. Roadside near Wells, S, GC and CJC. This plant is favoured by the salting of roads.

Draba muralis L. In 1987, Sandford Hill, Winscombe, S, RH. Several large plants in old walls between Chilcompton and Clapton, S, J. Kemp and (later) RSC.

Cardamine bulbifera (L.) Crantz A good flowering patch, wooded area of Fosse Lane, Batheaston, S, RSC.

Rorippa palustris (L.) Besser Chew Valley Lake, where also *R. sylvestris* (L.) Besser, and Cheddar Reservoir, S, RSC.

Viola canina L. In 1988, Weston Moor, Gordano, S, RH. Not seen here for many years.

Hypericum maculatum Crantz Several vigorous plants on railway embankment, Clink Road Junction, Frome, S, RSC.

H. humifusum L. A few plants in rough acid grassland, Priddy, S, RSC. Also rides in Leigh Woods, Bristol, S, RH and D. Lawrence.

Silene vulgaris (Moench) Garcke Marshy waste ground, Lamplighters Marsh, Shirehampton, Bristol, G, IFG. Also Portbury Wharf, S, RSC.

Cerastium pumilum Curtis In 1988, disused railway track, Writhlington, S, RDR.

Atriplex laciniata L. A few small colonies of this species, which is uncommon in the Bristol area, on sand dunes, Berrow, S, PJMN.

Tilia cordata Miller King's Castle Wood, near Wells, S, RSC. Also *Polystichum setiferum* (Forsskål) Woynar.

Malva neglecta Wallr. Abundant on road verge, Shirehampton, Bristol, G, IFG. Also *Allium oleraceum* L. on road verge and *Saponaria officinalis* L. on rough ground.

Lavatera arborea L. A young plant, strandline, north of Severn Beach, G, CK and MARK. This is the first record away from a garden for this vicinity for many years.

Linum bienne Miller In 1988, several plants under the M5 Avon Bridge on a raised bank above the saltmarsh, Pill, S, ALG.

Genista tinctoria L. One plant in ungrazed green lane, Lower Stone, G, CK & MARK.

Trifolium squamosum L. Portbury, S, IG. Not recorded in this vicinity since 1921.

T. fragiferum L. Riverside marshland, Pill, S, IFG. Also *Epilobium obscurum* Schreb. and *Apium graveolens* L. by the Avon at Pill.

Hippocrepis comosa L. The colony in Leigh Woods, Avon Gorge, Bristol, reported in 'Bristol Botany in 1963', p. 380, persists and has extended, S, PJMN.

Onobrychis viciifolia Scop. A few plants in disturbed ground, Cheddar, S, RSC.

Vicia orobus DC. Several plants of the white-flowered form, grassy bank, near Long Wood, Charterhouse, S, APP.

Lathyrus sylvestris L. With *Myosotis laxa* Lehm. ssp. *caespitosa* (C.F. Schultz) Hyl. ex Nordh. and *Ononis spinosa* L., Portbury Wharf, S, RSC.

Rubus × *idaeoides* Ruthe (*R. caesius* L. × *R. idaeus* L.) In 1988, by Brown's Folly, Bathford, S, and by the Dundas Aqueduct, Monkton Combe, S, RDR.

R. longus (Rogers & Ley) Newton In 1988, Warleigh Wood, Bath, S, RDR, conf. AN.

R. rudis Weihe & Nees In 1988, waste ground and hedges, North End, Batheaston, S, RDR, det. AN.

R. insectifolius Muell. & Lefèv. In 1988, abundant in Friary Wood, Hinton Charterhouse, S, RDR, det. AN.

R. rufescens Muell. & Lefèv. In 1988, Friary Wood, Hinton Charterhouse, S, RDR.

R. *raduloides* (Rogers) Sudre In 1988, Peasedown St John; Friary Wood, Hinton Charterhouse; and Walcot, Bath; all S, RDR.

R. angusticuspis Sudre In 1988, Greyfield Wood, Clutton, S, and Lord's Wood, ensford, S, RDR, conf. AN.

Potentilla anglica Laicharding A small flowering and fruiting patch, peaty bank of rhyne, Weston Moor, Gordano, S; also good patch on Westhay Moor, S, RSC.

Geum × *intermedium* Ehrh. (*G. rivale* L. × *G. urbanum* L.) Hedgebank, West Harptree, S, RSC.

Aphanes microcarpa (Boiss. & Reut.) Rothm. On limestone heath, Burrington, S, J. G. Keylock.

Rosa micrantha Borrer ex Sm. A single bush above the railway line between Sea Mills and Shirehampton, G, PJMN. A few bushes in the Lion Rock area, Cheddar Gorge, S, where work by The National Trust at the south-west end of the Gorge is opening up habitats to *Rosa* and *Sorbus* previously not easily accessible, PJMN. Also, in 1986, by Monkswood Reservoir, St Catherine, near Bath, S, DG, det. Rev. G. G. Graham.

Prunus avium (L.) L. Two trees, Vallis Vale, S, RSC.

Sorbus eminens E. F. Warburg At least one shrub, in shade, Sandford Wood, Sandford, S, PJMN. On National Trust property at the south-west end where some of the cliffs at Cheddar, S, have been cleared, but as many *Sorbi* retained as possible, *S. eminens* has typical fruit though its leaves are smaller and thicker than normal, and with slightly differing teeth, morphological features that may arise from high exposure to wind and sun, PJMN. The taxonomic position of some other Cheddar *Sorbi* is problematical.

S. croceocarpa P. D. Sell The distribution of this taxon in the Avon Gorge and Sneyd Park, Bristol, G and S, was reported in 'Bristol Botany in 1986', p. 64, under the name *S. devoniensis* E. F. Warburg 'Theophrasta'. It is now described as a new species in a paper entitled 'The *Sorbus latifolia* (Lam.) Pers. aggregate in the British Isles' by P. D. Sell in *Watsonia*, 1989, Vol. 17 (Part 4), pp. 385-399 (the typification of *S. croceocarpa* and details of its distribution are given on pp. 392-395).

S. torminalis (L.) Crantz Three very large old standards, Hill Court Woods, Hill; three old trees, Church Hill Wood, Hill; and a dozen trees of mixed age at Catgrove, Upper Hill, G, CK and MARK. One tree at margin of Brinshaw Wood, near Yate Rocks, G, MARK. One large coppiced tree on woodland boundary, Sandford Wood, Sandford, S,

Lythrum portula (L.) D. A. Webb With *Myosotis laxa* Lehm. ssp. *caespitosa* (C. F. Schultz) Hyl. ex Nordh., plentiful in Brimble Pit Pool, Mendip; in small quantity in overgrown pool, Priddy; also several plants at margin of pool, Blackdown; all S, RSC.

Daphne laureola L. Nazareth House Wood, Stoke Bishop, Bristol, G, IFG.

Epilobium palustre L. Blackdown and also Brimble Pit Pool, Mendip, S, RSC.

Myriophyllum spicatum L. With *Ranunculus baudotii* Godron, Portbury Wharf, S, RSC.

M. alterniflorum DC. Dominant in small pond, Priddy, S, RSC.

Hippuris vulgaris L. Plentiful in pool, Compton Dando, S; also on dry mud, Cheddar Reservoir, S, RSC.

Torilis nodosa (L.) Gaertner Several flowering and fruiting plants on lawn area, Brent Knoll, S, RSC.

Bupleurum tenuissimum L. In plenty, flowering and fruiting after several years of apparent absence following damage to the salt marsh, south of Berkeley Nuclear Power Station, G, CK and MARK. It was not, however, seen at its sites in Somerset, RSC.

Apium inundatum (L.) Reichb. f. Still present and flowering in two pools on Mendip near Priddy (see R. G. B. Roe's *The Flora of Somerset,* 1981, p. 132), but in very small quantity in one of the sites, S, RSC.

Peucedanum palustre (L.) Moench A good patch in peat cutting, Westhay Heath, S, RSC. Also *Hydrocotyle vulgaris* L.

Euphorbia lathyrus L. Abundant, Windsor Place, Mangotsfield, G; persistent garden weed, Winterbourne Down, G, ALG.

E. exigua L. Hinton Charterhouse, S, RSC.

Polygonum rurivagum Jordan ex Boreau Plentiful, with *Scandix pecten-veneris* L. and *Euphorbia exigua* L., in arable field, Acton Turville, G, CK and MARK.

P. oxyspermum Meyer & Bunge ex Ledeb. ssp. *raii* (Bab.) D. A. Webb & Chater (*P. raii* Bab.) A single flowering and fruiting plant in sand near salt marsh, Sand Bay, Kewstoke, S, RSC. This taxon is very rare in v.c. 6.

Rumex × *dufftii* Hausskn. (*R. obtusifolius* L. × *R. sanguineus* L.) Woodland path, Penselwood, S, ACL.

R. maritimus L. In 1985, by Chew Valley Lake, S, J. Martin. Several plants in peat cutting, Shapwick Heath, S, RSC. These plants were just starting to flower on 11 July, whereas *R. palustris* Sm., present in greater quantity, was more advanced, with some plants in fruit.

Ulmus minor Miller Young trees, some 10-12 years old, developing from suckers, in several localities in the Bristol area, ALG. Hopefully these trees will reach maturity in the wake of the Dutch Elm disease.

Andromeda polifolia L. In 'Bristol Botany in 1970', p. 17, a few plants were reported from a peat bog 'south of Wedmore', in part of the Somerset Levels where the species had not been recorded since about the middle of last century. Some plants were stated by the finder, J.K. Hibberd, to be 'in full flower' (in July), and to have occurred in about six out of twenty-five quadrats randomly placed in the 15 acre plot (now a reserve of the Somerset Trust for Nature Conservation). The plant has not been seen again, although botanists have subsequently searched the area of Westhay Moor involved, and doubts have been cast on the 1970 record (this is not included in the paper by R.G.B. Roe entitled 'Losses and threatened losses from the Somerset Flora' in the *Proceedings of the Somerset Archaeological and Natural History Society* for 1985/86, Vol. 130, pp. 193-199).

An error in determination in 1970 seems unlikely, as the plant was in flower. C.G. Trapnell, who bought the area concerned for the STNC, refers (*in litt.* 1990) to J.K. Hibberd's 'precise and detailed recording', and has 'no reason whatever to doubt the accuracy' of this. Changes in the area since 1970, including peat cutting, might well have led to the loss of the plant here as in other parts of the Levels, including the Shapwick area, where it was known to have persisted until 1920. It is of interest, however, that *A. polifolia* has continued to exist in several areas where it had been believed lost or not to grow. One such record refers to Somerset. J. W. White (*Flora of Bristol*, 1912, p. 414) excludes its occurrence on Mendip whence it was reported last century. Nevertheless, on 4 November 1914 Mrs C. I. Sandwith conducted J. W. White to Blackdown-on-Mendip, where the plant, although described as 'fragile' and 'nearly smothered in tussocks of rush, heather etc.' (annotation by CIS in her copy of White's *Flora*), was in flower (see 'Bristol Botany in 1914', p. 140). The plant was last seen at this site in 1928, subsequent searches by PJMN over several years being unsuccessful. Regrettably *A. polifolia* now appears to be extinct in both the Somerset Levels and Mendip.

Limonium vulgare Miller In small quantity, with *Artemisia maritima* L., Kingston Pill, Kingston Seymour, S, CK and MARK.

Hottonia palustris L. In 1986, Grumblepill rhyne, Banwell, S, RH.

Anagallis tenella (L.) L. A small patch at pool margin, Blackdown (see 'Bristol Botany in 1968', p. 488), and persists in small quantity in nearby site known since 1975, S, RSC.

Samolus valerandi L. In small quantity bordering rhyne close to sea wall, near Hill Pill, CK and MARK. Several plants in rhyne behind sea bank, Portbury Wharf, S, RSC.

Cynoglossum officinale L. With *Anchusa arvensis* (L.) Bieb. and *Marrubium vulgare* L., plentiful in disturbed ground of lower slopes of Brean Down, S, RSC. Also, in 1988, Dolebury Warren, Churchill, S, RH.

Symphytum tuberosum L. Marksbury, S, RAJ.

Echium vulgare L. In 1988, old quarry, Sandford, S, Miss S. Tucker.

Verbascum nigrum L. Four plants on roadside bank, at entrance to Mells Park, S, RSC and also PG. Two plants were normal coloured and two cream coloured.

V. virgatum Stokes One plant in quarry, Uphill, S, RSC.

Linaria vulgaris Miller Plentiful in rough ground between Crook Peak and Compton Hill, S, PJMN. This plant may be a relic of former unsuccessful (or wartime) cultivation here (White's *Flora of Bristol*, 1912, p. 455, notes that the Common Toadflax is occasionally abundant among crops, as at Churchill and Shipham).

Chaenorhinum minus (L.) Lange Several plants in cornfield, Hinton Charterhouse, S, RSC, where *Kickxia spuria* (L.) Dumort. also plentiful.

Orobanche elatior Sutton Hellenge Hill, Bleadon, S, EJM. First record in v.c. 6 since 1953.

O. minor Sm. One large spike in rough grassland, apparently on *Carduus nutans* L., Bleadon, S, RSC.

Calamintha sylvatica Bromf. ssp. *ascendens* (Jordan) P.W. Ball Several plants at wood margin, Banwell Hill, S, RSC.

Lamium hybridum Vill. Arable field, Portbury, S, RH. The Cut-leaved Deadnettle is rare in v.c. 6.

Campanula glomerata L. One plant at edge of track, Callow Hill, S, RSC.

Legousia hybrida (L.) Delarb. Cornfields, Corston and Marksbury, S, RDR.

Asperula cynanchica L. Near Brimble Pit Pool, Mendip, S, RSC, where also *Campanula rotundifolia* L.

Galium odoratum (L.) Scop. With *Lithospermum officinale* L. and *Veronica montana* L., King's Castle Wood, near Wells, S, RSC.

Valerianella carinata Loisel. Several plants near old cemetery, Wells, S, RSC.

Filago minima (Sm.) Pers. In 1988, slag heap, Pensford, S, RH and RAJ.

Achillea ptarmica L. A small patch on railway embankment, Frome, S, RSC.

Chrysanthemum segetum L. In 1987, King Down, Blagdon, S, RH.

Artemisia maritima L. In very small quantity on sea bank, Portbury Wharf, S, RSC.

Carduus nutans L. A good patch of white-flowered plants amongst those of normal colour, Stert Point, S, RSC.

Centaurea cyanus L. In 1986 by Chew Valley Lake, S, RH.

Hieracium trichocaulon (Dahlst.) Johans. Abundant on stone revetment of aqueduct, Harptree Combe, S, RMP. This hawkweed was recorded here by B. W. Tucker in 1917.

Butomus umbellatus L. Several plants dumped at side of rhyne after clearing, Berkeley Moors, G, MARK. A few flowering plants in rhyne, Puxton, S, RSC.

Potamogeton polygonifolius Pourret Brimble Pit Pool, near Priddy, S, RSC.

P. pusillus L. Burtle Moor and in two places on Street Heath, S, RSC.

P. berchtoldii Fieber With *Ranunculus trichophyllus* Chaix, pool, Charterhouse, S, RSC.

Zannichellia palustris L. Portbury Wharf, S; Tealham Moor, S; and Walton Moor, Gordano, S, RSC.

Paris quadrifolia L. A few plants, with plentiful *Polygonatum multiflorum* (L.) All., King's Castle Wood, near Wells, S, RSC.

Juncus compressus Jacq. A fruiting patch on concrete surrounds of water margin, Cheddar Reservoir, S, RSC.

J. maritimus Lam. In 1986 and 1988, salt marshes, Portbury, S, RH. Not recorded in this vicinity since 1920.

J. acutus L. About eight large tussocks in damp part of golf course, Weston-super-Mare, S, M. Griffith and (later) RSC. This rush is known to have been present for several years but is believed to have been planted.

Spiranthes spiralis (L.) Chevall. Frequent, Shute Shelve, S, PJMN.

Orchis morio L. A few plants, two pale coloured, Fortnight, S, RSC.

Scirpus maritimus L. Binham Moor, north of Mark, S, RSC. This club-rush is noted for its inland occurrence in Somerset.

S. sylvaticus L. A few plants in overgrown area on side of By Brook, Bathford, S, RSC.

Schoenoplectus lacustris (L.) Palla ssp. *lacustris* Bank of River Avon, Eastwood Farm, Brislington, Bristol, S, IFG. Also in this vicinity were *Lythrum salicaria* L., the terrestrial form of *Polygonum amphibium* L., *Arctium lappa* L. and *Impatiens glandulifera* Royle.

S. lacustris (L.) Palla ssp. *tabernaemontani* (C.C. Gmelin) A. & D. Löve A fine stand, old oxbow, south of Berkeley Pill, Berkeley Nuclear Power Station, G, MARK.

Blysmus compressus (L.) Panz. ex Link In 1987, by pond on golf course, Weston-super-mare, S, S. Hedley and RH. Although formerly known in a number of sites in v.c. 6, the Flat-headed Sedge is now very rare.

Cyperus fuscus L. A substantial number of quite large flowering plants, Walton Moor, Gordano, S, RSC and SW. This was the plant's best performance since 1976 when there was a very dry summer. It was unusually luxuriant after the great drought of 1921 (see 'Bristol Botany in 1920 and 1921', p. 200).

Carex demissa Hornem. Blackdown, Mendip, S, RSC.

C. acutiformis Ehrh. Bathford, S, RSC.

C. pendula Huds. Moist ground flanking the railway line between Sea Mills and Shirehampton, G, PJMN.

C. *montana* L. In limestone grassland, Burrington Combe, S, RSC.

C. acuta L. By Blagdon Lake, S, RH and D. Lawrence.

Poa compressa L. Lost from wall, after repointing, Winterbourne Down, G, ALG. *Poa nemoralis* L. was abundant nearby on wall tops.

Catabrosa aquatica (L.) Beauv. Roadside rhyne, Shapwick Heath, S, and plentiful in peat cutting, Street Heath, S, RSC.

Koeleria vallesiana (Honckeny) Gaudin Several plants, stony turf, Loxton Hill, S, RSC.

Avenula pubescens (Hudson) Dumort. With *Koeleria macrantha* (Ledeb.) Schultes, Banwell Castle Hill, S, RSC.

Calamagrostis epijegos (L.) Roth This grass appears to be steadily increasing, forming extensive patches in some places at Shute Shelve and also Crook Peak and Wavering Down to the west, S, PJMN. A large patch is near track, Compton Hill, S, and there are several large stands on Shapwick Heath, S, RSC.

Gastridium ventricosum (Gouan) Schinz & Thell. Bower's Hill, Ben Knowle Hill and Hay Hill, near Wells, S, and Lodge Hill, Westbury-sub-Mendip, S, PG and IG. The Nit Grass seems to be a more widespread component of south- and south-west-facing limestone grassland than previously realized.

ALIENS

Azolla filiculoides Lam. In roadside pond, cleared about a year previously, forming a rim about a metre wide, Upper Morton, Thornbury, G, CK and MARK.

Paeonia officinalis L. *'rubra-plena'* One plant of this well-known garden form on roadside bank at Bromley Heath, Downend, G, ALG. *Stachys byzantina* C. Koch and *Centaurea montana* L. previously recorded here still thrive.

Papaver atlanticum (Ball) Coss. Several plants on roadside, Abbots Leigh, S, ALG. The forma *flore pleno* appeared spontaneously in garden, Winterbourne Down, G, ALG.

Cardaria draba (L.) Desv. Lane running parallel to disused railway line, Fishponds, Bristol, G; roadside on Bridgeyate Common, Warmley, Bristol, G; on A4174 roundabout at Hambrook, G; roadside, Winterbourne, G, all ALG.

Isatis tinctoria L. Roadside, Henton, S, Mrs J. Appleyard. The Woad is an escape from a garden where it was grown as a source of dye; the first record for Somerset since 1906.

Barbarea intermedia Boreau In 1988, a single plant under motorway bridge, Lyde Green, Mangotsfield, G, ALG. In 1988, waste ground, Odd Down, Bath, S, DG.

Amaranthus retroflexus L. A few flowering plants on dumped soil, grass verge, Axbridge, S, RSC. Arable field, Portbury, S, RH.

A. hybridus L. Abundant, but later cut by roadmen, in two areas adjoining fields with vegetable crops, where hedges removed, roadside from Lower Morton to Rockhampton, G, CK and MARK.

A. albus L. Roadside bank, Axbridge, S, IG.

Kochia scoparia (L.) Schrad. Several plants on roadside, Cumberland Basin, Bristol, G, ALG. *Sorghum halepense* (L.) Pers., previously reported here, continues to expand.

Malope trifida Cav. One plant on verge of the newly completed Downend to Blackhorse section of the A4174 Bristol ring road, G, ALG. This showy malvaceous garden annual, originating in Spain, is recorded for the first time in the Bristol area. Also in quantity on the verge was *Helianthus annuus* L., plants ranging from one foot to nine feet tall. Other species present were *Anthemis cotula* L. (a few plants), *Panicum miliaceum* L., *Setaria viridis* (L.) Beauv. and *S. pumila* (Poir.) Schultes, ALG.

Cassia obtusifolia L. (*C. tora* auct., non L.) This is the correct identity of the plant reported under *C. occidentalis* in 'Bristol Botany in 1987'. Quantities appeared again in 1988 and 1989, in Avonmouth Docks, G, ALG (see also *B.S.B.I. News*, 1984, 36, p. 28)

Rubus cissburiensis Barton & Riddelsd. Probably spreading from gardens, Bath, S, RDR, det. AN.

Duchesnea indica (Andr.) Focke Disused colliery, Writhlington, S, IG.

Prunus cerasus L. Edge of golf course, in rough grass and scrub, Shirehampton, Bristol,G IFG.

P. mahaleb L. A small tree was reported in 'Bristol Botany in 1957', p. 345, established opposite the Zoo, Durdham Down, Clifton, Bristol, G. The St. Lucie Cherry was noted by A.L. Grenfell in 'A review of the alien and introduced plants of the Avon Gorge' (these *Proceedings* for 1987, Vol. 47, p.36) as perhaps still present in the scrub opposite the Zoological gardens. Although badly damaged by fire several years ago, the tree survives and thrives, PJMN.

Cotoneaster buxifolius Wallich ex Lindley One large bush, presumably bird-sown, churchyard wall, West Harptree, S, RMP, det. JF.

C. dielsianus Pritzel Churchyard wall, Chew Magna, S, and top of wall, Dundry, S, RMP, det. JF.

C. franchetii Bois Top of wall, Pensford, S, RMP, det. JF.

C. sternianus (Turrill) Bonn Wall-top, Felton, near Winford, S, and bridge over River Chew, Ford, S, RMP, det. JF.

C. × *watereri* Endl. Wall-top, Chew Stoke, S, and wall-top, Chew Magna, S, RMP, det. J.R. Palmer.

Pyracantha coccinea M.J. Roem. One plant on derelict ground behind Old Market Street, Bristol, G, ALG.

Sorbus decipiens (Bechst.) Irmisch This 'Sharp-toothed Whitebeam' was first seen on the Clifton side of the Avon Gorge, G, in the Great Quarry in 1956. A row of saplings had been planted behind the iron fence on the quarry side away from the tennis courts (which then occupied much of the Great Quarry). The identity of this tree has been established and the species described by P. D. Sell in *Watsonia,* 1989, Vol. 17 (Part 4), pp. 386-387. A number of the original trees have been lost but there is some small regeneration. The only other specimen known in the Bristol area is a large planted tree in the grounds of a property in Bramble Lane, Sneyd Park, Bristol, G, PJMN.

Sedum dasyphyllum L. Old walls, Wookey, S, GC and CJC.

S. reflexum L. On rough ground on road verge, Shirehampton, Bristol, G; also at edge of path by the Avon, Pill, S, IFG.

Tellima grandiflora (Pursh) Dougl. ex Lindl. Appeared in garden in 1988, Winterbourne Down, G, ALG. Overgrown and no longer to be seen near the top of Nightingale Valley, Leigh Woods, Bristol, S, ALG.

Lythrum junceum Banks & Sol. With *Hibiscus trionum* L., both bird-seed aliens, garden, Winterbourne Down, G, ALG.

Smyrnium olusatrum L. Fairly plentiful but very short, Sand Point, S, CK and MARK.

Ammi majus L. Two plants, Back of Bridge Street, central Bristol, G, PJMN.

Solanum rostratum Dunal Two plants in flower and fruit, roadside bank, Axbridge, S, RSC and also IG.

Verbascum blattaria L. A white-flowered form, later destroyed, on building site, Nazareth House Grounds, Stoke Bishop, Bristol, G, IFG, det. ALG.

Misopates orontium (L.) Rafin. In 1988 a few plants noted in the disused Portishead Docks, S, on BNS Field Meeting, per ALG. A single plant in carrots, garden, Compton Martin, S, APP. The Lesser Snapdragon is an uncommon weed in Somerset.

Salvia verticillata L. In quantity, roadside, Bower Ashton, Bristol, S, ALG.

Leonurus cardiaca L. A garden escape on roadside, Winterbourne Down, G, ALG.

Senecio fluviatilis Wallr. Westbury Moor, near Westbury-sub-Mendip, S, PG.

Anaphalis margaritacea (L.) Bentham A small fruiting patch, quarry, Cloford, S, RSC.

Cicerbita macrophylla (Willd.) Wallr. Border of Downs, Henleaze, Bristol, G, IFG.

Hieracium speluncarum Arv.-Touv. On stonework, close to the Floating Harbour, near Castle Park, Bristol, G, PJMN. This is an extension of its range from the Clifton area.

Juncus tenuis Willd. In 1988, Friary Wood, Hinton Charterhouse, S, RDR.

J. subulatus Forsskål This rush has been lost from the site in the salt marsh at Berrow, S, from which it was first described (see *Watsonia*, 1960, Vol. 4 (Part 5), pp. 211-217). This part of the marsh has received much blown sand in recent years which seems to have overwhelmed the colony, A.J. Willis. Fortunately the plant has thoroughly established some distance further south in the marsh, in association with *Phragmites australis* (Cav.) Trin. ex Steudel (dominant or co-dominant) and *Scirpus maritimus* L. It has been known in this more southerly site since 1974, RSC. The Berrow salt marsh was the only recorded station for this plant in Britain until 1983 when a small patch (probably arising from a single plant) was found near Grangemouth, Stirlingshire (see *Watsonia,* 1984, Vol. 15 (Part 2), p. 171).

Allium paradoxum (Bieb.) G. Don Plentiful in lane, Batheaston, and in very small quantity by the Avon to the west, S, RSC.

Bromus inermis Leyss. In 1986, Bedminster, Bristol, S, Anna Roxburgh.

B. willdenowii Kunth Axbridge, S, PG.

Gaudinia fragilis (L.) Beauv. Disused railway track, Kilmersdon, S, PG and IG.

Polypogon monspeliensis (L.) Desf. A bird-seed alien in D.O.E. Rehabilitation Centre, Fishponds, Bristol, G, ALG.

Echinochloa crus-galli (L.) Beauv. One plant on dumped soil, grass verge, Axbridge, S, RSC. Also two plants of *Setaria viridis* (L.) Beauv.

Panicum capillare L. This grass, and also *Centaurea diluta* Ait. and *Physalis angusta* L., appeared as garden weeds, Winterbourne Down, G, ALG. The first two species are known as bird-seed aliens but the origin of *P. angusta,* a tropical weed, is unknown.

Very little of interest was noted at Avonmouth Docks, G, apart from an unusually large showing of *Amaranthus albus* L. Waste from the vicinity of the Charles Ford Mill has been examined by Mr C.G. Hanson who reports the presence of seeds of the following: *Anoda cristata* (L.) Schlectend. var. *brachyantha* (Reichenb.) Hochr.; *Sida rhombifolia* L.; *Ipomoea hederacea* Jacq. and var. *integriuscula* Gray*; I. coccinea* L.; and *Cassia obtusifolia* L. No amaranths or grasses were identified, per ALG.

CHAROPHYTES

Chara vulgaris L. var. *vulgaris* This common charophyte, previously reported under its synonym var. *refracta* Kütz. from rhines on Walton Moor and Weston Moor, Gordano, S (see 'Bristol Botany in 1957', p. 350), persists in numerous recently cleared peaty ditches on these moors (nine localities noted), NFS, SW and EJM. In one site on Weston Moor and another near the junction of Walton and Weston Moors was a form with a few long spines, approaching var. *papillata* Wallr. ex A. Braun.

C. vulgaris L. var. *longibracteata* (Kütz.) J. Groves & Bullock-Webster On recently managed peaty ditches on Walton and Weston Moors, Gordano, S, NFS and EJM.

C. vulgaris L. var. *papillata* Wallr. ex A. Braun In recently cleared peaty ditch, with some iron ochre, Weston Moor, Gordano, S, NFS and SW, conf. Jenny A. Moore.

C. hispida L. var. *major* (Hartm.) R.D. Wood In eight places in recently cleaned peaty ditches, Walton and Weston Moors, Gordano, S, NFS, SW and EJM.

C. globularis Thuill. var. *globularis* In a substantial number of recently cleaned peaty ditches, Walton and Weston Moors, Gordano, S, NFS, SW and EJM. In part of Weston Moor a larger form, fitting var. *hedwigii* Agardh, det. J.A. Moore, was also present.

C. globularis Thuill. var. *virgata* (Kütz.) R.D. Wood In nine sites, all in recently cleared ditches, Walton and Weston Moors, Gordano, S, NFS, SW and EJM (this taxon was reported from Walton Moor in 1925 under *C. delicatula* Agardh). In two recently cleaned ditches on Walton Moor an unusual form, with spines and stipulodes more developed than normal, was present, det. J.A. Moore as *C. globularis* var. *? virgata*.

C. pedunculata Kütz. In places along the entire length of a peaty ditch, not managed for over seven years, Weston Moor, Gordano, S, NFS and SW. Also present were *C. hispida* var. *major, Potamogeton coloratus* Hornem., *Juncus subnodulosus* Schrank and very short *Phragmites australis* (Cav.) Trin. ex Steudel. Although reported from the Gordano valley prior to 1960, there is no other record for *C. pedunculata* for south-west England.

Tolypella intricata (Trent. ex Roth) Leonh. One very small patch in recently cleaned peaty ditch, Weston Moor, Gordano, S, NFS. Although known in North Somerset prior to 1960, records of this charophyte in England since 1960 are restricted to a very few areas.

I thank everyone who has supplied records and helped with these, especially Mr P.J.M. Nethercott, Captain R.G.B. Roe and Mr A.L. Grenfell. I am indebted to Mr S.M. Taylor and to Long Ashton Research Station for meteorological records.

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SMALL MAMMALS IN A SPECIES-RICH HEDGEROW IN AVON

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INTRODUCTION

Hedgerows may often be the only wildlife habitat left in some areas. With the loss of woodland they provide conditions resembling woodland edge habitat, within which much of the UK's natural wildlife can survive. Whether the hedges are remnants of ancient woodlands, Saxon boundaries or more recent "Enclosure Act" hawthorn lines, they all provide protected sites for wild flowers and grasses, which in turn offer habitats for numerous species of insects. Hedgerows can therefore furnish small mammals with shelter, places and materials for building nests and supplies of food in the form of fruit, nuts, berries, leaves, seeds and insects.

For the past seven years biologists from the Ministry of Agriculture, Fisheries and Food's Wildlife and Storage Biology Unit (part of the Agricultural Development and Advisory Service) have been involved with a national survey of small mammals in farm hedgerows - a project initiated in 1983 by ADAS and the Mammal Society. Two sites, one rich and one poor in shrub species, have been trapped in each of the six MAFF regions; the interim results from one site in the south-west are reported here. The hedgerow concerned runs along the Avon/Gloucestershire border near the villages of Rockhampton and Stone.

METHOD

Trapping took place twice a year, in the spring (late May - early June) and autumn (late November - early December). In each season trapping was carried out during one week; the traps were set on Monday afternoons and then checked morning and afternoon until Friday morning when they were taken up (4 trap nights).

At each site, Longworth live-catch small mammal traps were placed in two continuous lines along approximately 650 m of hedgerow (Figure 1). The first (line A) comprised 33 groups of 3 traps placed at 5m intervals, and the second (line B) had 25 groups of 4 traps at 20m intervals - a total of 199 traps. Line A was intended to catch all the voles and shrews at both high and low density and a reasonable sample of mice at high density. Line B was intended to catch all the mice at high and low densities, although some of the voles and shrews may have been missed because of the wider trap spacing. The traps were filled with hay and an ample supply of wheat to provide food for mice and voles, whilst shrews were provided with casters (blowfly pupae). Shrews are included in Schedule 6 of the Wildlife and Countryside Act 1981 (animals which may not be killed or taken by certain methods); ADAS staff are licensed by the Nature Conservancy Council to "take shrews by trapping", provided that they are released without delay at the site of capture.

Each captured animal was identified as to species and given a uniquely patterned fur-clip, to distinguish it on subsequent recapture. Age, weight, sex and breeding condition were recorded when the animals were first caught. The particular traps in

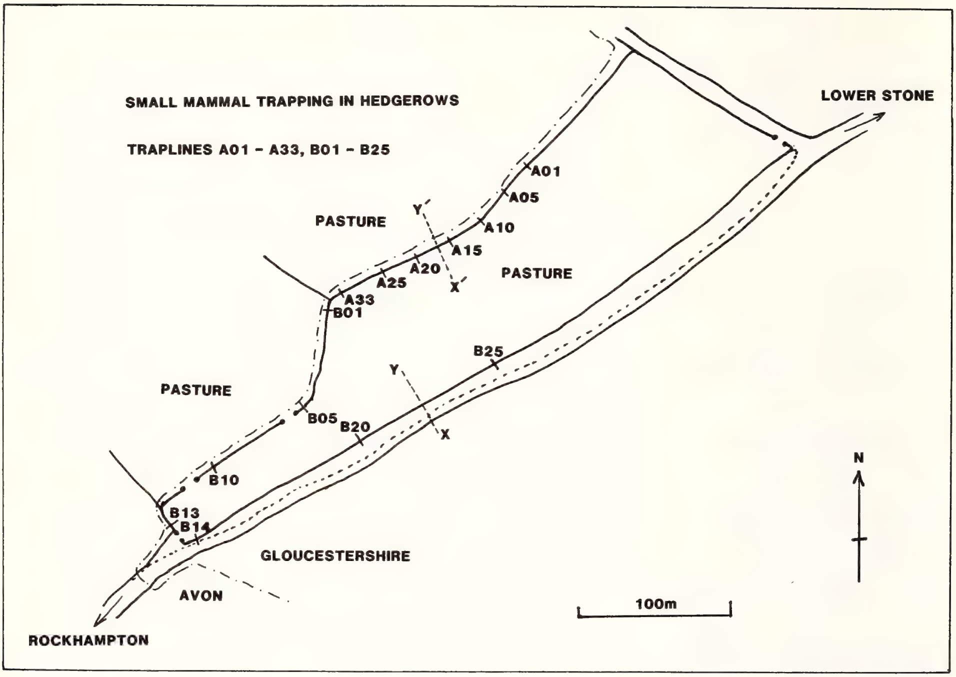
SMALL MAMMAL TRAPPING IN HEDGEROWS
TRAPLINES A01 - A33, B01 - B25
LOWER STONE
PASTURE
PASTURE
PASTURE
A01
A05
A10
A15
A20
A25
A33
B01
B05
B10
B13
B14
B20
B25
Y
X
Y
X
GLOUCESTERSHIRE
AVON
ROCKHAMPTON
N
100m

FIGURE 1. Map of trapping site on the Avon/Gloucestershire border.

which individuals were caught on each occasion were recorded so that their movements could be determined. Weather data (maximum and minimum temperatures, rainfall, presence or absence of dew, snow cover) and the moon's phase were also recorded. Detailed structural and botanical surveys of the hedgerows were made in the spring of 1987. Information on hedgerow and adjacent field management was also recorded, with a view to future analyses to identify those features which are good or bad for small mammals.

SITE DESCRIPTION

Line A and the first half of line B (Figure 1) followed the parish boundary (now also the county boundary) and so the hedge was wide (up to 3·5m) and tall (up to 5m) with standards of oak (*Quercus robur*), ash (*Fraxinus excelsior*), field maple (*Acer campestre*) and hazel (*Corylus avellana*) and a variety of other woody species, hawthorn (*Crataegus monogyna*) and blackthorn (*Prunus spinosa*) being dominant. Other woody species included dogwood (*Cornus sanguinea*), elder (*Sambucus nigra*), holly *(Ilex aquifolium*), privet (*Ligustrum vulgare*), rose (*Rosa canina*), spindle (*Euonymus europaeus*), willow (*Salix* sp.), bramble (*Rubus fruticosus*) and occasionally wild service tree (*Sorbus torminalis*). There was also a damp ditch about 1·2 m deep on the side of the hedge opposite the trap line location.

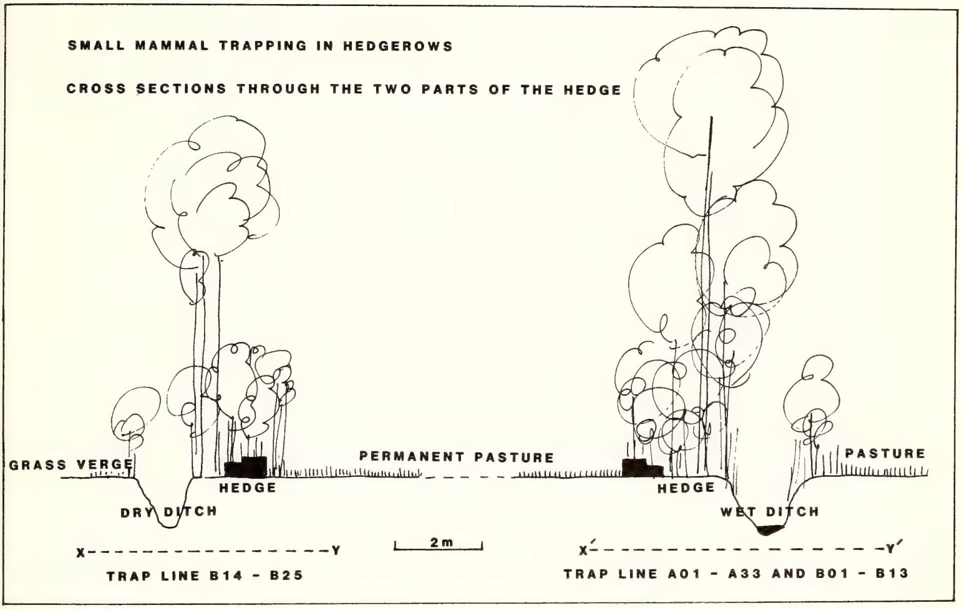
SMALL MAMMAL TRAPPING IN HEDGEROWS
CROSS SECTIONS THROUGH THE TWO PARTS OF THE HEDGE
GRASS VERGE
DRY DITCH
HEDGE
PERMANENT PASTURE
HEDGE
WET DITCH
PASTURE
X - Y
2 m
X′ - Y′
TRAP LINE B14 - B25
TRAP LINE A01 - A33 AND B01 - B13

FIGURE 2. Cross-section through the two parts of the hedge, indicated on Figure 1 (X - Y and X' - Y').

The second half of line B followed a hawthorn and blackthorn dominated hedge, on average 1·5m in height (regularly trimmed) and 2·5m wide with oak and ash standards; most of the species mentioned above were also present. There was a dry ditch about 1m deep on the outside of the hedge, a rough grassy verge up to 7m wide and then a tarred minor road. Figure 2 shows cross sections through the two parts of the hedge.

Climbing species were recorded in both sections of the hedge, including black bryony (*Tamus communis*), honeysuckle (*Lonicera periclymenum*), ivy (*Hedera helix*) and woody nightshade (*Solanum dulcamara*). The ground flora of both sections of hedge was varied but was fairly heavily grazed by cattle. The dominant species were ivy(*Hedera helix*), nettle (*Urtica dioica*) and several species of grass, including cocksfoot (*Dactylis glomerata*), rough-stalked meadow grass (*Poa trivialis*) and smooth-stalked meadow grass (*P. pratensis*). The field bordered by the hedge was permanent pasture, grazed at intervals throughout the season by cattle.

RESULTS

SMALL MAMMAL CAPTURES

Between 1984 and 1989, six species were trapped in the hedge: woodmouse (or long-tailed field mouse) (*Apodemus sylvaticus*), bank vole (*Clethrionomys glareolus*),

TABLE 1. Seasonal variation in the numbers of small mammals trapped in the hedge between 1984 and 1989 (*S*, spring; *A*, autumn)

	1984		*1985*		*1986*		*1987*		*1988*		*1989*	
	S	*A*	*S*	*A*	*S*	*A*	*S*	*A*	*S*	*A*	*S*	*A*
Woodmouse	1	45	9	35	6	34	-	53	20	45	3	29
Bank vole	10	35	28	22	10	35	12	5	16	8	11	15
Field vole	-	1	1	-	-	-	-	1	-	-	-	1
Water shrew	-	1	-	-	-	-	-	-	1	-	-	-
Pygmy shrew	-	3	-	8	2	-	2	1	-	-	-	7
Common shrew	2	17	22	31	13	14	21	15	7	4	9	16

TABLE 2. Deaths of small mammals in Longworth traps. (Of the 4 field voles and 2 water shrews trapped, none died.)

	Season	*Woodmouse*	*Bank vole*	*Common shrew*	*Pygmy shrew*
1984	Spring	-	-	1	-
	Autumn	-	2	3	-
1985	Spring	-	1	-	-
	Autumn	1	2	8	1
1986	Spring	-	-	5	1
	Autumn	-	2	6	-
1987	Spring	-	-	1	-
	Autumn	3	-	2	-
1988	Spring	-	-	2	-
	Autumn	-	-	-	-
1989	Spring	-	-	-	-
	Autumn	-	-	2	-
Totals					
	Spring	-	1	9	1
	Autumn	4	6	21	1
Captures					
	Spring	39	87	74	4
	Autumn	241	120	97	19
Mortality (percent.)					
	Spring	-	1·2	12·2	25·0
	Autumn	1·7	5·0	21·7	5·3

TABLE 3. Woodmouse and bank vole age classes.
A, adult; *S*, sub-adult; *J*, juvenile.

Season		*Woodmouse*			*Bank vole*		
		A	*S*	*J*	*A*	*S*	*J*
1984	Spring	-	1	-	3	5	-
	Autumn	15	22	8	21	12	1
1985	Spring	8	1	-	17	11	-
	Autumn	4	24	3	4	6	4
1986	Spring	6	-	-	6	4	-
	Autumn	12	13	1	21	9	3
1987	Spring	-	-	-	12	-	-
	Autumn	22	27	-	4	1	-
1988	Spring	13	5	2	9	5	2
	Autumn	25	20	-	2	6	-
1989	Spring	2	1	-	9	1	-
	Autumn	14	14	1	10	5	-
Spring							
	Total	29	8	2	56	26	2
	Percent.	74	21	5	67	31	2
Autumn							
	Total	92	120	15	62	39	8
	Percent.	41	53	6	57	36	7

common shrew (*Sorex araneus*), pygmy shrew (*S. minutus*), short-tailed field vole (*Microtus agrestis*) and water shrew (*Neomys fodiens*).

Of the 687 individuals trapped in 9552 trap-nights, 41% were woodmice, 30% bank voles and 25% common shrews. The numbers trapped fluctuated quite markedly from season to season (Table 1). This was especially noticeable with woodmice which showed distinct seasonal changes; numbers were highest in the autumn and lowest in the spring. No woodmice were captured in spring 1987, but they had returned by that autumn and 53 were caught. Bank vole numbers showed some seasonal fluctuations but, as Flowerdew (*in* Corbet & Southern, 1977) reported, numbers do vary considerably from season to season and year to year.

TRAP MORTALITY (Table 2)

The overall mortality of small mammals within the traps was 6·3% (43/687): 5·4% in the spring and 6·7% in the autumn. There were no woodmouse deaths in the spring and only a 1·7% mortality in the autumn. Bank vole figures were 1·2% and 5·0% for spring and autumn. Common shrew mortality was 12·2% and 21·7% for spring and autumn

TABLE 4. Male woodmouse and bank vole breeding condition.
TA, testes abdominal; *TM*, testes medium; *TL*, testes large.

Season		*Woodmouse*			*Bank vole*		
		TA	*TM*	*TL*	*TA*	*TM*	*TL*
1984	Spring	1	-	-	5	-	-
	Autumn	18	3	-	8	-	-
1985	Spring	4	1	1	12	1	-
	Autumn	18	3	-	5	2	-
1986	Spring	-	-	3	2	3	-
	Autumn	11	-	-	6	-	-
1987	Spring	-	-	-	2	4	3
	Autumn	19	-	1	1	-	-
1988	Spring	1	2	8	2	3	2
	Autumn	12	14	1	1	1	-
1989	Spring	-	-	1	-	2	3
	Autumn	5	-	-	5	-	-
Spring							
	Total	6	3	13	23	13	8
	Percent.	27	14	59	52	30	18
Autumn							
	Total	83	20	2	26	3	-
	Percent.	79	19	2	90	10	-

respectively. Shrews have always been difficult to keep alive in traps and it is likely that the high autumn mortality was due to cold - small mammals are prone to hypothermia, especially if the bedding within the traps gets wet. Also, shrews caught soon after the traps had been serviced may have eaten all the available casters and succumbed before the next visit (up to 20 hours later).

AGE RATIOS (Table 3)

The age of animals trapped was divided into three classes: 1, *adult*, at the upper end of their weight range and showing obvious signs of breeding; 2, *sub-adult*, of intermediate weight and not yet in full breeding condition; 3, *juvenile*, at the lower end of the weight range and still showing the greyer juvenile fur colour. No attempt was made to age common shrews.

Woodmice In the spring, 74% were classified as adults, dropping to 41% in the autumn.

Bank Voles In the spring 67% were classified as adults, dropping to 57% in the autumn.

TABLE 5. Female woodmouse and bank vole breeding condition. *IM*, imperforate; *IP*, parous; *PE*, perforate; *PP*, pregnant; *PL*, pregnant and lactating; *LA*, lactating.

Season		*Woodmouse*						*Bank vole*					
		IM	*IP*	*PE*	*PP*	*PL*	*LA*	*IM*	*IP*	*PE*	*PP*	*PL*	*LA*
1984	Spring	-	-	-	-	-	-	-	2	2	-	-	-
	Autumn	19	1	-	-	-	3	23	1	-	-	-	-
1985	Spring	-	1	2	-	-	-	6	2	4	2	1	-
	Autumn	11	1	-	-	-	-	13	-	-	-	-	-
1986	Spring	-	1	1	-	-	-	2	-	2	-	-	-
	Autumn	12	-	-	-	-	-	19	6	-	-	-	-
1987	Spring	-	-	-	-	-	-	-	1	1	1	-	-
	Autumn	21	5	-	-	3	-	2	2	-	-	-	-
1988	Spring	7	-	1	1	-	-	5	3	-	1	-	-
	Autumn	9	4	5	-	-	-	6	-	-	-	-	-
1989	Spring	16	-	-	1	-	-	1	2	-	-	2	-
	Autumn	10	-	-	-	-	-	6	3	-	1	-	-
Spring													
Total		8	2	4	2	-	-	14	10	9	4	3	-
Percent.		50	12	25	12	-	-	35	25	23	10	7	-
Autumn													
Total		82	11	5	-	3	3	69	12	-	1	-	-
Percent.		80	11	5	-	2	2	84	15	-	1	-	-

BREEDING CONDITION (Tables 4 and 5)

Data was collected on the breeding condition of all the animals caught except shrews, which were not included because of the difficulty in accurately determining their sex (and hence their breeding condition). Three classes of breeding condition in males were recorded: TA, *testes abdominal*; TM, *testes medium*; and TL, *testes large*, in full breeding condition. Six classes of breeding condition in females were recorded: IM, *imperforate*, usually the condition of immature animals; IP, *parous*, females that have been reproductively active; PE, *perforate*, females that have recently been mated; PP, *pregnant*, females that are obviously pregnant; PL, *pregnant and lactating*; and LA, *lactating*, females that have given birth and have young still dependent on them.

Woodmice 59% of the males trapped in the spring were in full breeding condition (i.e. with fully developed testes), falling to 2% in the autumn (Table 4). Half the females trapped in the spring showed some signs of reproductive activity but only 12·5% were obviously pregnant; in the autumn, only 20% showed signs of reproductive activity Only 18% of the males trapped in the spring were in full breeding condition, falling to zero by the autumn (Table 4). 65% of the females trapped in the spring showed evidence of breeding, falling to only 16% by the autumn (Table 5).

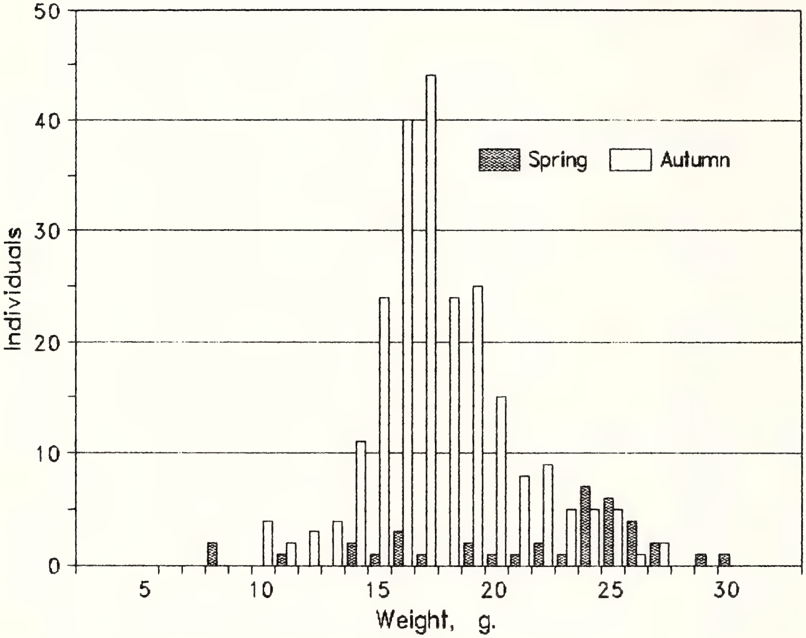

FIGURE 3. Woodmouse, spring and autumn weight profiles.

Means and 95% confidence limits	*spring*	*autumn*
All ages	21·37 ± 1·77g	16·61 ± 0·38g
Excluding juveniles	22·17 ± 1·46g	16·83 ± 0·37g

Bank voles Only 18% of the males trapped in the spring were in full breeding condition, falling to zero by the autumn (Table 4). 65% of the females trapped in the spring showed evidence of breeding, falling to only 16% by the autumn (Table 5).

WEIGHTS (Figures 3-5)

There were considerable seasonal variations in the weights of the small mammals trapped. The mean weights were significantly higher in the spring than in the autumn. Most of the animals around in the spring would be adults from the previous year, in peak condition for the breeding season and therefore at their maximum weight.

Woodmice (Figure 3) The mean weight of adults and sub-adults in autumn was 16·83g; in spring it was 22·17g, nearly one-third higher. The weight range was greater in the spring, with individuals weighing 7 - 29g compared with 10 - 26g in the autumn. Those at the lower end of the range were juveniles and immature animals. Flowerdew (1984) reported that in winter woodmice weigh 16-18g and in summer 25-27g, with old males or pregnant females reaching up to 37g.

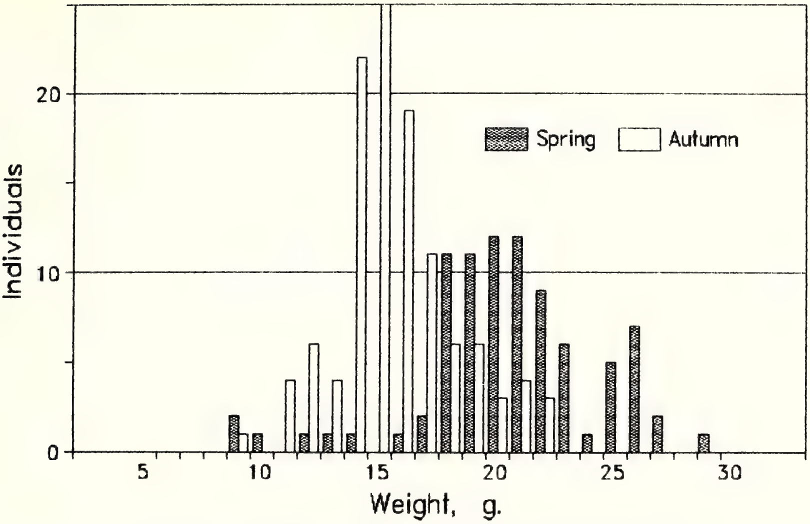

FIGURE 4. Bank vole, spring and autumn weight profiles.

Means and 95% confidence limits	*spring*	*autumn*
All ages	20·48 ± 0·46g	15·69 ± 0·73g
Excluding juveniles	20·75 ± 0·80g	15·32 ± 0·61g

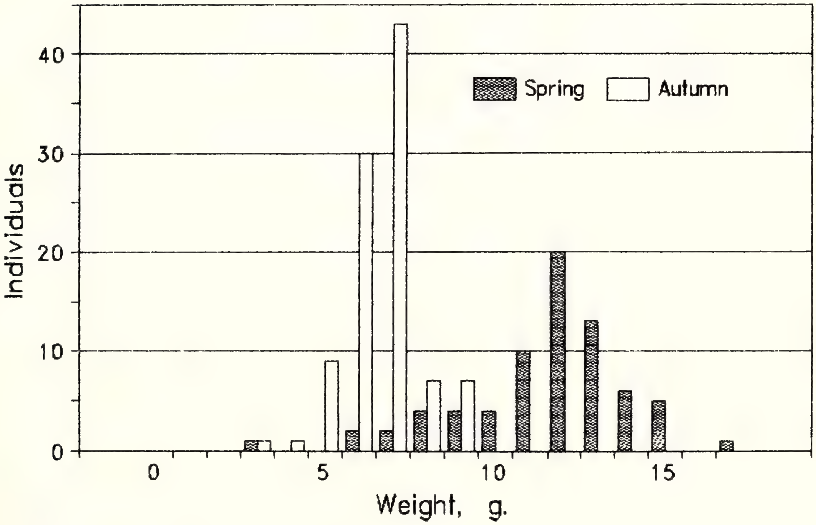

FIGURE 5. Common shrew, spring and autumn weight profiles.
Means and 95% confidence limits, all ages:
spring, 11·56 ± 0·56g; *autumn*, 6·63 ± 0·21g.

Bank voles (Figure 4) In spring the mean weight of adults and sub-adults was some 35% greater than in autumn, 20·75g compared with 15·32g. Also, as with the woodmice the range of weights encountered was greater in the spring (9 - 29g) than in the autumn (9 - 22g). Flowerdew (*in* Corbet & Southern, 1977) reported that weight increases as bank voles come into breeding condition, and decreases after breeding and also during the winter.

Common shrews (Figure 5) In spring the mean weight was 11·56g, some 75% greater than the autumn mean of 6·63g. Again, the weight range in spring (3 - 17g) was greater than in the autumn (3 - 9g). According to Churchfield (1986), individual shrews reach their minimum weight between December and February and their maximum by the summer. The reasons for this weight gain are not related to food availability and are still not fully understood.

DISCUSSION

HABITATS AND FOOD SUPPLIES

Pollard & Relton (*in* Corbet & Southern, 1977) reported that bank voles do not move far into fields and are seldom trapped more than 2m from cover. They are almost totally herbivorous, eating fruit, leaves of woody plants, dead leaves, and only occasionally such things as moss, lichen, flowers, insects, etc. Field voles made up less than 1% of the total caught and are, as their name suggests, most often found in rough, ungrazed grasslands, with only low densities in marginal habitats like woodland (Corbet & Southern, 1977).

Wood mice (also called long-tailed field mice) are found where there is a reasonable amount of cover and are the characteristic small rodents of woodland, hedgerows and fields. They feed on a wide variety of seedlings, fruit, nuts, birds, snails and arthropods, depending on the season.

Common shrews too are very widespread, being found in a broad variety of habitats. They are most abundant in thick grass and hedgerows. Pygmy shrews also live in a wide variety of habitats but tend to be less abundant than common shrews. Heydemann (*in* Corbet & Southern, 1977) stated that only 12% of shrews (common and pygmy) in woodland and woodland edge are pygmy shrews. In the present study 23 out of 194 shrews caught, or 11·8%, were pygmy shrews. However, it should be noted that pygmy shrews are likely to be much less efficiently sampled by Longworth traps than are the heavier common shrews. Both species eat a wide variety of soil and litter invertebrates, especially earthworms and beetles. Water shrews usually live near rivers, streams and ponds but can often be found in woodland and hedgerows some distance from water. There was always water in the ditch that ran alongside the hedge at the Avon study site.

BREEDING SEASONS AND POPULATIONS

Male woodmice are fecund in March. Most pregnancies occur in July or August, with the length of the breeding season usually depending on food availability. In this study, nearly 60% of males were in full breeding condition by early June (Table 4); only 12·5% of females were pregnant at that time (Table 5). In the spring, the population consists of young born late in the last breeding season and a few adults from the previous year. By the end of May, a few of the year's young are beginning to appear and many of the over-wintering sub-adults mature into adulthood (Table 3); their weights at this time of year show a very wide spread, from 7g juveniles to old adults and pregnant females at 29g. The increase in numbers following breeding is most noticeable from the late summer onwards, reaching a peak in October or later. Numbers then decline to a low point in March and April. This annual cycle is clearly demonstrated in Table 1.

As with woodmice, the bank vole breeding season starts in March or April and usually ends in September or October, although a good food supply may prolong the season considerably. The overwintering population again consists of a few adults and late-born young. Numbers usually reach a maximum in late summer or early autumn, declining to a low point in April or May. Newson & Southern (*in* Corbet & Southern, 1977) reported much variation on this theme, with numbers of voles often remaining high in the winter and spring and declining in the summer and autumn. The results of this project certainly show wide seasonal fluctuations in numbers (Table 1).

Common shrews usually breed in their second spring and summer; the breeding season lasts from early March to late September. Shrews undergo a weight loss, as yet unexplained, during the winter, reaching minimum weight in January and maximum by mid summer. The weight profiles for shrews (Figure 5) show this clearly, the mean autumn weight being 6·6g and the mean late spring weight 11·6g.

Much more information can and will be extracted from the data so far collected, for example: 1, analyis of capture, mark and recapture (all the mammals trapped were individually marked) to gain information on population densities and movements of individual animals; 2, further analysis of male/female weight variations between spring and autumn; 3, analysis of the effects of hedgerow structure and shrub species composition on small mammal populations; 4, analysis of the effects on small mammal populations of the management of hedgerows and of the adjacent fields; and 5, analysis of the weather data, phase of moon, etc., in relation to small mammal populations, movements and survival. Poulton & Swash (1987) have suggested that the effects of hedgerow management and adjacent land use seem to be more important to small mammals than does the species composition of the shrub and ground flora.

The site described in this paper is one of twelve hedgerow sites being studied in England and Wales. So far around 133,000 trap nights of data have been collected nationally making it one of the largest and longest running studies of small mammals in the UK. The whole project is due to be reported nationally at the end of the study period and it is hoped that guidelines on the management of hedgerows and the adjoining fields can then be drawn up, showing how to provide the optimum habitats for small mammals.

SUMMARY

1. Small mammals were trapped using Longworth live small mammal traps in spring and autumn in a floristically species-rich hedgerow adjoining permanent pasture.
2. In all 687 individuals of six species were trapped in 9,552 trap nights: woodmouse (*Apodemus sylvaticus*) 41%, bank vole (*Clethrionomys glareolus*) 30%, common shrew (*Sorex araneus*) 25%, pygmy shrew (*S. minutus*) 3%, short tailed field vole (*Microtus agrestis*) <1%, and water shrew (*Neomys fodiens*) <1%.
3. Numbers of woodmice showed distinct seasonal fluctuations, with small numbers in the spring and large numbers in the autumn. Bank voles showed less seasonal variation, and common shrews showed no obvious seasonal variation in numbers.

4. Overall trap mortality was 5·4% in the spring and 6·7% in the autumn. Mortality was highest amongst common shrews, 12·2% and 21·7% in the spring and autumn respectively.
5. The proportion of adults amongst the woodmice and bank voles trapped was higher in the spring than in the autumn.
6. 59% of male woodmice and 18% of male bank voles trapped in the spring were in full breeding condition. These figures fell to 2% and zero respectively in the autumn. 50% of female woodmice and 65% of female bank voles showed signs of reproductive activity in spring, but only 20% and 16% respectively did so in the autumn.
7. Woodmice, bank voles and common shrews were considerably heavier in the spring than in the autumn.

ACKNOWLEDGEMENTS

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EFFECTS OF THE ADDITION OF MINERAL NUTRIENTS ON THE VEGETATION OF THE AVON GORGE, BRISTOL

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INTRODUCTION

The vegetation developed on soils deficient in certain mineral nutrients may be substantially changed, and the productivity much increased, by the addition of these nutrients. Such changes are particularly pronounced in dune systems, where the major nutrients nitrogen, phosphorus and potassium may be limiting, as at Braunton Burrows, North Devon (Willis, 1963). Here, in dunes and also slacks, the addition of complete nutrients enhanced both the height and the fresh weight of the vegetation substantially, in one site as much as fifteen-fold and seven-fold respectively. In other ecosystems, elements other than nitrogen, phosphorus and potassium may be in limiting supply, as in the South Haven Peninsula (Studland), Dorset, where several trace elements are deficient (Willis, 1985a). The sparse growth, the open character of the vegetation and also its species- richness in these dune systems are associated with their low levels of particular mineral nutrients (Willis & Yemm, 1961; Willis, 1963, 1985a, b, 1989), diversity being much reduced when these deficiencies are made good.

The rather thin, open vegetation of some parts of the precipitous east (city) side of the Avon Gorge, and its species-richness as well as its high number of rare species (Willis, 1962; Houston, 1988) may be associated, as in dune systems, with low levels of some mineral nutrients in the soil derived from the Carboniferous Limestone. In order to investigate this situation, a simple mineral nutrient experiment was carried out at two sites in the Gully area of the Avon Gorge. Additions of nutrients were made over a period of three years (1964 - 1967) and changes in the vegetation were monitored. The chief findings are reported here.

SITES AND METHODS

The study sites were in the Gully area of the Avon Gorge, near Sea Walls, overlooking the Portway. The higher site was near the top of the Gully, at about 230 ft O.D. (Grid Reference ST 563746); the other site was part-way down the slope at about 140 ft O.D. (Grid Reference ST 562744) in Walcombe Slade. Both sites were in the vicinity of the Gully Oolite of the Carboniferous Limestone Series (Bradshaw & Frey, 1989).

The site near the top of the Gully was a south-facing rocky ledge, moderately sloping, with a rather thin soil, which was bare in places and with some rock exposure. Scattered bushes of gorse and privet were nearby, as well as areas of scree. The mid-slope site was facing west-north-west, moderately sloping, on deeper soil, more completely vegetated and with less rock outcropping. Although this area was essentially open limestone grassland, bushes of hawthorn and a few of guelder rose were scattered in this part. A number of small ridges (mostly about 5-10 cm high) were a distinctive feature here.

At each site typically representative areas (chosen visually) of 11 ft × 11 ft were marked out by small wooden pegs and skewers, and subdivided into nine squares, each 3 ft x 3 ft, with a

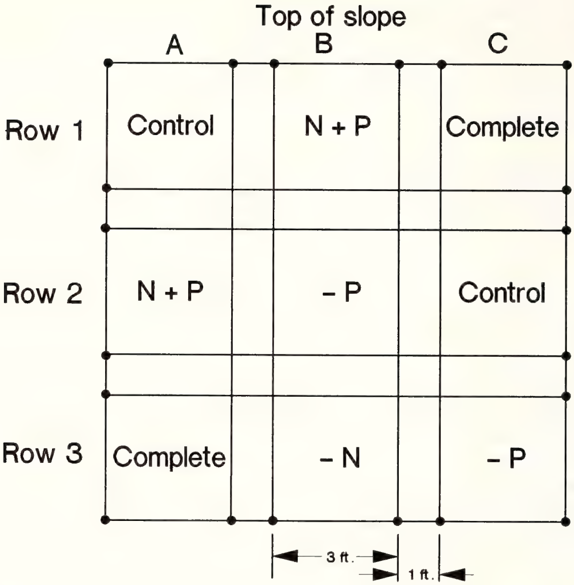

FIGURE 1. The layout and mineral nutrient treatments of the two experimental sites in the Gully.

'path' (for access in recording) 1 ft wide between the squares (Figure 1). The nine squares (units), each of 1 square yard (0.84 m^2), permitted a layout similar to that of a Latin Square, except that there were four treatments besides a control (untreated), so one treatment (nitrogen deficient) was not replicated, and the other treatments and control were replicated only once (Figure 1). Minimal disturbance of the sites was obviously desirable; fortunately no damage was found over the whole period of study. When recordings were made, strings were run out from the marker pegs to delimit the nine units.

The four treatments were: complete nutrients; nitrogen and phosphorus (N + P); nutrients lacking phosphorus (– P); and nutrients lacking nitrogen (– N). The composition of the mineral salts added is given in Table 1, the levels being based on those used to correct deficiencies in agricultural practice and as used in similar studies previously (Willis, 1963). In the complete nutrient treatment phosphorus was added as diammonium hydrogen phosphate and nitrogen as ammonium sulphate, together with potassium sulphate and magnesium sulphate, the latter being added to all areas. In the N + P treatment phosphorus was added as disodium hydrogen phosphate and nitrogen as sodium nitrate. Both sites are strongly calcareous (with soil pH mostly of about 7·8); no calcium was added to any area. Trace elements were added only in the complete nutrient treatment, the N + P treatment differing from this mainly in the lack of potassium (not thought to be deficient in the area) and of minor nutrients.

The salts were crushed, well mixed and spread by hand as uniformly as possible over the appropriate units. Seven applications of mineral salts were made at each site, on the dates of the first seven recordings of the vegetation, the first in April 1964 and the last in May 1967

TABLE 1. The composition of the mineral salts applied to the vegetation (grammes per square yard) for the four treatments; small quantities of Fe, B, Mn, Zn, Cu and Mo were also added (as given by Willis, 1963) to the complete nutrient treatment only.

Treatment	*Complete*	*N + P*	*– P*	*– N*
$(NH_4)_2HPO_4$	21·2	–	–	
Na_2HPO_4 (anhyd.)	–	22·8	–	22·8
$(NH_4)_2SO_4$	10·4	–	31.8	-
K_2SO_4	21·2	–	21·2	21·2
$NaNO_3$	–	41·0	–	-
$MgSO_4.7H_20$	42·4	42·4	42·4	42·4

(see Tables 3 and 6). In all, eight recordings were made, one in the spring of each year, one in the autumn for the years 1964 to 1966 and one in the summer of 1967. The vegetation was assessed by the subjective method described by Willis *et al.* (1959). An arbitrary total of 10 was divided, by visual observation, between bare soil, exposed rock and vegetation on an area basis. The total value assigned to vegetation was then distributed among the species in proportion to their above-ground bulk (biomass), as judged subjectively. Estimates were made to the nearest quarter, though they have been rounded to halves as the precision of the estimates was found to be essentially within about 5%. Where only small quantities of plants were involved they were recorded as Traces (T), usually (except where many small species were present in very tiny amounts) given the arbitrary score of 0·1. The average height of the vegetation was also noted.

At the end of the experiment, after the final subjective assessment had been made, the vegetation of a few of the squares was clipped to ground level, sorted by species on site, placed in polythene bags and their fresh weights determined as soon as possible in the laboratory. Quite close agreement was found, with few exceptions, between the subjective estimates and the results of the weighings. To minimize damage, clipping was confined to the mid-slope site and here only one square (the lower in each case) was clipped of the control, and of the complete, - P and – N treatments. The relative proportions of the species calculated from the weighings of the clippings from these squares are given in Tables 6, 7 and 8, alongside the subjective estimates. Replicate squares showed quite closely similar behaviour, so results for only one of each treatment (or control) are given for each site.

Nomenclature of vascular plants follows that of Clapham *et al.* (1987); the common names of species referred to in this paper are given in Table 2. The detailed tabulated results list (with very few exceptions) only those species of fairly wide occurrence which made up at least 5% of the total bulk of the vegetation in at least some of the squares.

TABLE 2. Latin and common names of flowering plants referred to in the text and tables.

Acinos arvensis	Basil-thyme
Anthyllis vulneraria	Kidney-vetch
Arabis stricta	Bristol Rock-cress
Avenula pratensis	Meadow Oat
Brachypodium pinnatum	Heath False-brome
Briza media	Quaking Grass
Bromus erectus	Upright Brome
Carex flacca	Carnation-grass
Carex humilis	Dwarf Sedge
Carex serotina	Small-fruited Yellow Sedge
Centaurea nigra	Lesser Knapweed
Cerastium pumilum	Curtis's Mouse-ear Chickweed
Crataegus monogyna	Hawthorn
Dactylis glomerata	Cock's-foot
Festuca ovina	Sheep's Fescue
Festuca rubra	Red Fescue
Helianthemum nummularium	Common Rockrose
Hieracium pilosella	Mouse-ear Hawkweed
Hippocrepis comosa	Horse-shoe Vetch
Hornungia petraea	Rock Hutchinsia
Ligustrum vulgare	Common Privet
Lotus corniculatus	Birdsfoot-trefoil
Odontites verna	Red Bartsia
Picris hieracioides	Hawkweed Ox-tongue
Pimpinella saxifraga	Burnet Saxifrage
Plantago lanceolata	Ribwort Plantain
Poa subcaerulea	Spreading Meadow-grass
Quercus ilex	Holm Oak
Rubia peregrina	Wild Madder
Sanguisorba minor	Salad Burnet
Saxifraga tridactylites	Rue-leaved Saxifrage
Scabiosa columbaria	Small Scabious
Stachys officinalis	Betony
Thymus praecox	Wild Thyme
Trinia glauca	Honewort
Ulex europaeus	Gorse
Viburnum opulus	Guelder Rose

RESULTS

TOP OF GULLY SITE

Control units

At the start of the experiment, on 13 April 1964, there was a substantial amount of bare ground (19%) and of exposed rock (18%) in the nine squares, taken together. *Festuca ovina*

TABLE 3. The composition of the main components of the vegetation of an untreated (control) unit (1A) of the Latin Square at the top of the Gully site, based on eight subjective estimates made from 1964 to 1967. Assessment times: *1*, 13 April 1964; *2*, 7 September 1964; *3*, 6 April 1965; *4*, 15 September 1965; *5*, 31 March 1966; *6*, 28 September 1966; *7*, 5 May 1967; *8*, 17 July 1967). For method of assessment see text. T, trace.

Assessment times	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Bare ground	1½	1½	1½	½	1	½	½	½
Exposed rock	2	2	2½	2	1½	1	1	1
Bromus erectus	½	1	½	1	½	1	½	½
Festuca ovina	½	½	1	1	½	½	1	1
Carex humilis	½	½	½	T	½	½	½	½
Anthyl. vulneraria	T	½	½	½	T	½	½	½
Arabis stricta	-	-	-	-	-	-	-	-
Heli. nummularium	½	½	½	½	½	½	1½	1½
Hippocrepis comosa	-	-	-	-	-	-	-	-
Sanguisorba minor	1	1	1	1	1½	1½	2	1½
Trinia glauca	T	T	T	T	½	½	T	T
Ulex europaeus	3	2	1½	3	3	3	2	2½
Other species	½	½	½	½	½	½	½	½
Total species	16	12	14	14	18	17	16	17
Average height (cm)	5	7	5	10	5	12	11	13

(18%), *Anthyllis vulneraria* (11%), *Helianthemum nummularium* (7%), *Bromus erectus* (7%) and *Ulex europaeus* (7%) were the main contributors to the vegetation in the nine squares. There were smaller amounts of *Carex humilis, Sanguisorba minor, Trinia glauca, Hippocrepis comosa* and *Arabis stricta*. Minor components were *Acinos arvensis, Cerastium pumilum, Hieracium pilosella, Picris hieracioides, Saxifraga tridactylites, Scabiosa columbaria* and seedlings of *Crataegus monogyna* and *Quercus ilex*. The average number of species per square (unit) was 16 and the average height of the vegetation in April 1964 was 5 cm. Altogether 26 species were recorded in the nine squares at the initial assessment.

Over the study period there was only little change in the vegetation of the control (untreated) units (Table 3). The vegetation remained short, the mean heights for the two replicate units, taken together, in April and September for the years 1964-1966 being 5 cm and 9 cm respectively. Species diversity remained quite high throughout the investigation.

TABLE 4. The floristic composition of the vegetation of units (3A, 2A) at the top of the Gully site treated with complete nutrients and with N + P. For asessment times see legend of Table 3.

	Complete								*N + P*							
Assessment times	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Bare ground	2	1½	1	½	½	½	T	T	1½	1½	1	1	½	½	T	T
Exposed rock	2	2	1½	1	1	½	½	T	1	1	1	1	½	½	½	T
Brom. erect.	½	2	2½	3	2½	4½	3	4	1	1	2½	2½	1½	3½	2½	2½
Fest. ovina	1	1	2½	2½	3½	2½	3½	4	3½	3	3½	2	5	4	5	6
Carex hum.	½	½	T	T	T	T	½	T	T	½	T	T	T	T	T	T
Anth. vuln.	2½	1	½	T	T	T	-	T	1	½	T	T	T	-	T	-
Arabis str.	T	-	T	½	T	-	-	-	T	-	T	T	T	-	-	-
Heli. numm.	T	½	T	½	½	½	½	½	½	1	½	1	½	T	T	T
Hip. comosa	-	-	-	T	-	-	-	-	T	T	T	T	T	T	T	T
Sang. minor	T	½	½	½	½	½	½	½	½	T	T	½	T	½	½	½
Trinia gl.	T	T	½	T	½	T	½	T	T	T	T	T	½	T	½	T
Ulex euro.	-	-	T	T	T	-	-	-	T	½	½	1	½	T	T	-
Other spp.	1	1	½	1	½	½	1	½	½	½	½	½	½	½	½	½
Total spp.	16	14	16	14	16	12	13	8	18	12	14	15	16	11	13	10
Ave. ht (cm)	4	11	6	10	7	22	16	27	7	12	7	10	8	14	15	28

There was some reduction in the amount of rock exposed, but no species showed any marked trend of change. Although in unit 1A there was some increase in *Helianthemum nummularium* and *Sanguisorba minor* over the years (Table 3), this was not shown in unit 2C. In the latter *Anthyllis vulneraria* made up a somewhat higher proportion and *Ulex europaeus* a lower proportion of the vegetation.

Complete nutrients and N + P units

The effects of complete nutrients and of the N + P treatment were closely similar and so are conveniently considered together. As Table 4 shows, both treatments led to progressive reduction of bare ground and exposed rock and much increased height. At the end of the experiment (17 July 1967) the average height of the vegetation for all of the units with these treatments was 29 cm, compared with that for the control (untreated) units of 13 cm. Species diversity was also much reduced, from a mean value per unit at the final assessment of 15 species in the controls to 9 species in the treated units.

TABLE 5. The floristic composition of the vegetation of units (3C, 3B) at the top of the Gully site treated with nutrients lacking phosphorus (– P) and lacking nitrogen (– N). For assessment times see legend of Table 3.

	–P								*–N*							
Assessment times	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Bare ground	3	2½	2	1	1	½	½	T	2	1½	1½	½	½	½	½	½
Exposed rock	1½	1½	1½	1	1	1	1	½	2	2	2	1½	1	1½	1	1
Brom. erect.	1	1	1½	1	1	1½	2	2	1	1	1½	1	1½	2	1½	1
Fest. ovina	2	1½	1½	1	1	1	2	2	1½	1½	2	1½	2	1½	2½	2½
Carex hum.	T	½	T	½	T	½	T	1½	T	T	½	T	T	T	½	½
Anth. vuln.	1	½	½	1½	2½	½	½	½	1½	½	T	1½	1½	½	T	-
Arabis str.	T	T	T	T	T	T	T	T	T	T	T	T	T	-	-	-
Heli. numm.	T	½	½	½	½	½	½	½	½	1	½	½	1	1	½	1½
Hip. comosa	T	½	½	½	½	1	½	T	-	T	-	T	-	T	T	T
Sang. minor	½	½	½	½	½	1	1	1	T	½	½	½	½	½	½	1
Trinia gl.	T	T	T	T	T	T	T	½	T	½	½	½	T	½	1	½
Ulex euro.	T	½	1	2	1½	2	1½	1	½	½	½	1½	1	1½	1½	1½
Other spp.	½	½	T	½	T	T	T	T	½	½	½	½	½	½	½	T
Total spp.	13	12	12	14	14	12	15	14	17	15	15	13	14	13	15	9
Ave. ht (cm)	5	7	4	6	4	11	13	23	5	9	6	9	5	12	12	20

Very large increases were found in the grasses *Bromus erectus* and *Festuca ovina* as a result of the mineral nutrient additions. Overall the relative bulk of *Bromus erectus* increased during the period of the study by more than four-fold and that of *Festuca ovina* by more than two-fold, these two species becoming extremely strongly dominant. They finally made up more than three-quarters of the total vegetation in most of the units. Clear declines were shown by *Anthyllis vulneraria* and *Arabis stricta*. On the other hand there was little change in the abundance of *Carex humilis, Helianthemum nummularium, Sanguisorba minor* and *Trinia glauca*.

Phosphate-deficient units

The addition of nutrients lacking phosphorus led to a slow increase in productivity, and heights were substantially greater in the final year of the study (Table 5). In one unit, species diversity showed little change, but in the replicate there was a reduction. Both bare ground and exposed rock were reduced with the progressive growth of the vegetation, the main increases finally being of *Bromus erectus, Carex humilis* and *Ulex europaeus. Anthyllis*

TABLE 6. The floristic composition of the main components of the vegetation of an untreated (control) unit (2C) at the mid-slope Gully site, based on eight subjective assessments made from 1964 to 1967. Assessment times: *1*, 23-28 April 1964; *2*, 8 Sept. 1964; *3*. 9 April 1965; *4*, 15 Sept. 1965; *5*, 31 March 1966; *6*, 28 Sept. 1966; *7*, 5 May 1967; *8*, 12 July 1967. The final column (*8**) gives the values for the major components in the last assessment, based on the fresh weights of clippings.

Assessment times	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*8**
Bare ground	-	T	-	T	T	T	T	T	
Exposed rock	½	1	½	½	½	½	½	½	
Avenula pratensis	½	T	½	½	½	½	T	½	½
Briza media	T	½	½	½	½	½	½	½	T
Bromus erectus	1	½	½	½	½	1	½	½	½
Dactylis glomerata	-	-	-	-	-	-	-	-	-
Festuca ovina	2½	1½	3	2½	3	2	2	1½	2½
Carex humilis	½	1½	½	1	1	1½	½	1	1
Helianthemum numm.	½	1	½	½	½	½	1	1	1
Hippocrepis comosa	T	½	T	½	T	½	T	½	½
Sanguisorba minor	½	1	½	½	½	½	1	½	½
Pseudoscl. purum	2½	1	2½	1½	2	1½	2½	2½	2½
Other species	1½	1½	1	1½	1	1	1	1	1
Total no. of species	23	25	18	25	21	20	22	24	
Average height (cm)	7	6	5	8	5	10	9	18	

vulneraria declined with the increase of *Bromus erectus,* whereas the replicates indicated little change in the relative proportions of *Helianthemum nummularium, Hippocrepis comosa, Sanguisorba minor* and *Trinia glauca.*

Nitrogen-deficient unit

Treatment with nutrients lacking nitrogen resulted in an increase in height of the vegetation and a decrease in bare ground and exposed rock similar to the effects of phosphate-deficient nutrients (Table 5). There was, however, a gradual reduction in species diversity. The clearest increases were shown by *Festuca ovina, Sanguisorba minor* and *Ulex europaeus,* and there was some increase in *Helianthemum nummularium.* Species adversely affected were *Anthyllis vulneraria* and *Arabis stricta* which were not seen in the final assessment. *Trinia glauca,* however, maintained its performance, and there was little change in *Bromus erectus* and *Carex humilis.*

MID-SLOPE GULLY SITE

Control units

The deeper and somewhat moister soil of the mid-slope site had a more closed vegetation than that of the site at the top of the Gully, with less bare ground and exposed rock and also greater species-richness (Table 6). At the start in April 1964 there was about 90% ground cover, of which the chief component was the moss *Pseudoscleropodium purum* (22%). Next most abundant were *Festuca ovina* (15%), *Bromus erectus* (11%) and *Carex humilis* (7%). Less plentiful grasses were *Avenula pratensis, Brachypodium pinnatum* and *Briza media*. The dicotyledons which were most abundant were *Helianthemum nummularium* (6%), *Sanguisorba minor* (4%) and *Hippocrepis* comosa (2%). Less frequent were *Acinos arvensis, Hieracium pilosella, Lotus corniculatus, Plantago lanceolata, Rubia peregrina, Scabiosa columbaria* and *Thymus praecox*. In all some 37 species were recorded in the whole experimental area.

The assessments of the untreated units indicate marked constancy in the vegetation (Table 6), no species showing a clear increase or decrease. The average height of the vegetation was similar to that of the site at the top of the Gully, but the species diversity was higher, averaging 24 species per unit at the start. In the weighed clippings of unit 2C (Table 6) at the end of the study, *Pseudoscleropodium purum* and *Festuca ovina* each contributed about a quarter of the above-ground biomass, and *Carex humilis* and *Helianthemum nummularium* each made up about one-tenth. This unit had a somewhat lower amount of *Bromus erectus* than its replicate. The total fresh weight of the clippings (from 0·84 m^2) was nearly 300g.

Complete nutrients and N + P units

As in the top of the Gully site, the effects of the complete nutrients and of the N + P treatment were very similar and are considered together (Table 7). There was a substantial increase in growth and a considerable loss of species diversity. With the progressively larger amounts of *Bromus erectus* and *Festuca ovina,* bare ground diminished. There were also considerable losses of *Pseudoscleropodium purum,* especially in the first year. *Carex humilis* was much reduced, and also *Briza media,* as well as *Brachypodium pinnatum* in the units where this grass occurred. There were some reductions in the relative bulk of *Helianthemum nummularium, Hippocrepis comosa* and *Sanguisorba minor*. *Dactylis glomerata* invaded three of the units, but in only very small amounts in two of them. Fresh weights of the above--ground clippings at the end of the experiment showed that some 90% of the vegetation was made up by grasses, mostly *Bromus erectus* and *Festuca ovina,* the dicotyledonous plants contributing only about one-tenth of the weight. The total fresh weight from one of the complete nutrient units (3A) was 536g, about double that of the units not receiving nitrogen together with phosphorus.

Phosphate-deficient units

Additions of mineral nutrients lacking phosphorus led to only little increase in height of the vegetation, but there was some loss of diversity (Table 8). Changes in the proportions of the grasses were small, although *Bromus erectus* increased in one replicate. The major dicotyledonous plants also showed rather little change. The most striking effect of the treatment was the progressive increase of *Carex humilis* from some 5% of the vegetation initially to about 30% in July 1967. This sedge was particularly abundant at the edge of minor ridges or 'steps' which seem to favour its growth. *Pseudoscleropodium purum* was quickly reduced to small quantities. In unit 3C, *Crataegus monogyna* made a substantial contribution to the 'other species'. In the clipping of this unit, the hawthorn was not included, the fresh weight

TABLE 7. The floristic composition of the vegetation of units (3A, 2A) at the mid-slope Gully site treated with complete nutrients and with N + P; for assessment times see legend of Table 6.

	Complete									*N + P*							
Assessment times	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*8**	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Bare ground	2	½	½	T	T	T	T	T		½	T	T	-	-	-	T	T
Exposed rock	-	T	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Avenula pr.	T	T	T	T	½	T	½	T	T	½	T	½	½	T	T	T	T
Briza media	T	½	½	T	T	-	-	-	-	T	½	½	T	T	T	T	T
Brom. erect.	1	2½	4	6	5	5	5	7	5	2	3	4½	5½	5	5½	6½	6
Dact. glom.	-	-	-	-	-	½	1	½	1	-	-	-	-	-	-	-	-
Fest. ovina	2	1½	2	2	3	2½	2	1½	3	1½	½	½	1½	2½	1	1½	2
Carex hum.	½	1½	1	½	½	½	½	T	T	1½	2½	1	½	T	T	T	T
Heli. numm.	½	½	T	T	T	T	T	T	T	½	½	T	T	T	½	T	T
Hip. comosa	½	½	½	T	T	T	T	T	T	T	T	-	-	-	T	-	-
Sang. minor	½	½	½	½	T	½	T	T	T	½	½	T	T	T	½	T	½
Pseud. pur.	2	1	T	T	T	T	T	T	T	1½	½	1	T	½	½	T	T
Other spp.	1	1	½	½	½	½	½	½	½	1½	1½	1½	1½	1½	1½	1½	1
Total spp.	19	19	15	11	12	12	12	14		20	17	14	14	15	17	15	14
Ave. ht (cm)	7	12	11	32	12	20	23	28		11	20	12	37	14	20	25	46

of the rest of the vegetation being just over 200g. *Carex humilis* and *Festuca ovina* each contributed about one-third of this weight.

Nitrogen-deficient unit

Treatment with nutrients deficient in nitrogen led to some increase in height, with reduction of bare ground, but with little change in species diversity which remained quite high (Table 8). There was some increase of *Festuca ovina* and invasion by *Dactylis glomerata* but other grasses tended to be reduced. *Carex humilis* showed little change. Most of the dicotyledonous species maintained their levels but there was an increase in *Helianthemum nummularium* which was the greatest contributor to the fresh weight (total of all of the vegetation for the unit was 277g) at the end of the study. The moss *Pseudoscleropodium purum* was quickly reduced to low quantities.

TABLE 8. The floristic composition of the vegetation of units (3C, 3B) at the mid-slope Gully site treated with nutrients lacking phosphorus (– P) and lacking nitrogen (– N); for assessment times see legend of Table 6.

	-P									*-N*								
Assessment times	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*8**	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*8**
Bare ground	1	1	1	½	1	½	½	T		1½	2	1	1	1	½	½	½	(½)
Exposed rock	1½	1½	1½	1½	2	2	1½	1	(1)	-	½	T	T	T	T	T	T	
Avenula pr.	½	T	½	½	½	T	T	T	T	1	1	1	1	1	½	½	½	½
Briza media	T	½	½	½	½	T	T	½	½	T	½	½	T	½	½	T	T	T
Brom. erect.	½	½	½	½	½	T	1	1	½	½	T	T	1½	½	½	½	½	T
Dact. glom.	-	-	-	-	-	-	-	-	-	-	-	-	T	T	½	½	1	1
Fest. ovina	2	2	2½	2	1½	2	2½	2	3	1½	1½	2½	1½	2	1½	2	2	2
Carex hum.	½	1	1	1	2½	3	1½	3	3	1½	1	2½	1	1½	2	1	1½	½
Heli. numm.	½	T	T	½	T	T	T	T	T	1	1	½	1½	2	2	2½	2	4
Hip. comosa	T	½	½	½	T	½	½	T		T	½	T	½	T	½	½	T	T
Sang. minor	½	½	½	½	T	T	½	½	½	½	½	½	½	T	½	½	½	½
Pseud. pur.	1	½	T	-	-	T	T	T		1½	½	T	T	T	T	½	T	T
Other spp.	2	2	1½	2	1	1½	1½	1½	1½	1	1	1	1	1	1	1	1	½
Total spp.	20	22	17	19	16	19	19	16		17	20	16	21	18	17	21	17	
Ave. ht (cm)	5	7	5	7	5	10	9	17		7	5	4	7	4	9	8	23	

DISCUSSION

The conspicuous effects arising from the additions of mineral nutrients demonstrate their importance in influencing the floristic composition of the vegetation as well as its production. The open character and fairly short stature of the vegetation and the diverse flora of the Avon Gorge are at least in part associated with low levels of some nutrients, although other features, such as shallow soil and liability to drought, are also important considerations.

Comparison of the natural vegetation of the top of the Gully site with that of the mid-slope site shows some appreciable differences, the mid-slope site, with deeper soil and moister conditions, having a richer flora; some species present in the latter site, such as *Centaurea nigra, Lotus corniculatus, Odontites verna, Pimpinella saxifraga* and *Stachys officinalis*, were infrequent in or absent from the site at the top of the Gully. In spite of these differences, observations at both of the experimental sites show close similarity between the effects of complete nutrients and the N + P treatment. The changes in floristic composition were very similar and productivity was high under both treatments. The results imply that the natural vegetation is not limited by potassium or by minor nutrients, none of these elements being included in the N + P treatment (and cf. treatment with complete nutrients).

The soils of the Avon Gorge derived from Carboniferous Limestone have an alkaline reaction (except where the surface has been much enriched with humus under trees and scrub), pH values at depths of 2-5 cm in the Gully ranging from about 7·4 to 8·3. Although these soils are frequently quite dry, they can hold about their own dry weight of water (and the organic top layer more than this). Values for organic carbon (at 2–5 cm) range from 2% to 10% of the dry weight. Calcium is not deficient, analyses showing levels of 100-250 mg per g dry weight of soil; in a mull soil from a limestone cliff near the experimental site Bowen & Dymond (1955) cited a pH value of 7·43 and a calcium content of 98,000 p.p.m. In spite of the alkaline reaction, there is no evidence from the mineral nutrition experiment of a lack of iron, neither were any visual symptoms of iron deficiency seen.

In both sites the grasses *Bromus erectus* and *Festuca ovina* showed pronounced increases with complete nutrients and the N + P treatment, and contributed largely to the high biomass under these treatments. This finding is similar to that on the dry dune pasture at Braunton Burrows, North Devon (Willis, 1963), where the grasses *Festuca rubra* and *Poa subcaerulea* became strongly dominant when complete nutrients were added. Limitations by nutrients in the Avon Gorge were not, however, as pronounced as at Braunton Burrows, the fresh weight (and height) being approximately doubled by the complete nutrient treatment, whereas in one site at Braunton Burrows fresh weight was increased seven-fold in two years (Willis, 1963).

The thick growth of the increased grasses with complete nutrients and the N + P treatment led to the reduction of a number of dicotyledonous plants, especially low-growing forms such as *Hippocrepis comosa* and *Hieracium pilosella*. These appeared to be out-competed and no doubt suffered reductions of light. In some places there were decreases in *Helianthemum nummularium* and *Sanguisorba minor;* in the mid-slope site *Pseudoscleropodium purum* was diminished from being a major component to trace quantities and acrocarpous mosses disappeared. At the site at the top of the Gully *Arabis stricta* was lost by the third year and *Cerastium pumilum* also from most of the treated areas. Small short-lived plants were adversely affected and conditions almost certainly became unfavourable for such species as *Hornungia petraea*. A cliff fire in the Gorge in 1984 was found to benefit this plant (Micklewright, 1986a), probably as a result of nutrients made available by the fire and also temporarily reduced competition, but such species cannot survive in a dense, tall grass cover. As at Braunton Burrows, high species diversity and the presence of rarities (Willis, 1985b) no doubt partly depend on infertility as well as on topographical features. In terms of conservation, increase in fertility is to be avoided.

Phosphorus was found to be a limiting nutrient to some extent at both of the study sites. In units receiving nutrients lacking phosphorus there was a small increase in the height of the vegetation but overall production was not appreciably enhanced. In these units and also in the untreated squares the major grasses *Bromus erectus* and *Festuca ovina* did not show the increased growth evident with complete nutrients. A striking effect of the – P treatment was to promote *Carex humilis,* especially in the mid-slope site, where this sedge increased from about one-twentieth of the vegetation to about one-third. This behaviour is similar to that of *C. flacca* and *C. serotina* which at Braunton Burrows (Willis, 1963) responded strongly to the addition of nutrients deficient in phosphorus. Like *C. flacca, C. humilis* may have a low phosphate requirement. Most if not all of the increase in *C. humilis* was attributable to vegetative spread, although the development of seedlings has been shown to occur in the Gorge (Lovatt, 1982, 1989).

In the areas receiving nutrients lacking nitrogen the small increase in height of the vegetation was associated with an improved performance of species such as *Festuca ovina* and *Helianthemum nummularium* which are relatively slow-growing (Grime *et al.*, 1988).

Overall, the chief elements limiting production in the Gorge and tending to keep the vegetation open appear to be nitrogen and phosphorus. The Gorge has long been famous for its large number of rare species (White, 1912; Hope-Simpson & Willis, 1955; Lovatt, 1982), many of which succeed best in small soil pockets or in a low, partly open sward, and are diversely affected by tree and scrub growth and prolific development of coarse grasses such as *Bromus erectus*. The apparently moderately low levels of available nitrogen and phosphorus result in a short vegetation and preserve its species-richness. It is desirable to maintain the open character of the habitat, not to enhance fertility, and to restrict the spread of productive grasses; these, at one time, were controlled to a considerable extent by grazing (Micklewright & Frost, 1989). It is also important to prevent overgrowth by scrub and tree cover (Micklewright, 1986b) to keep conditions favourable for a number of species for which the Gorge is renowned.

SUMMARY

1. Addition of mineral nutrients to two sites in the Gully, Avon Gorge, was found to have substantial effects on production of the vegetation and to lead to marked changes in floristic composition.

2. Treatment over a three-year period with complete nutrients approximately doubled the above-ground biomass, resulting in large increases of *Bromus erectus* and *Festuca ovina,* decreased species diversity and reductions of a number of dicotyledonous plants, including *Anthyllis vulneraria* and *Arabis stricta.*

3. The addition of nutrients containing nitrogen and phosphorus gave similar effects to complete nutrients, indicating no severe lack of elements other than N and P.

4. When nutrients lacking phosphorus were added, there was a striking increase of *Carex humilis,* but relatively little change in the grasses.

5. The low productivity, high species-richness and the large number of rare species of the Gorge appear to be, at least in part, associated with low levels of available nitrogen and phosphorus.

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THE EARLY ORDOVICIAN TRILOBITE *BELTELLA*

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ABSTRACT

The type species of the Ordovician (Tremadoc) trilobite *Beltella* is redescribed from well-preserved material from the Breadstone Shales in the Tortworth inlier, Gloucestershire. It is considered to be a pelturine olenid. Its peculiar thoracic structure renders it unlikely that it enrolled fully. The morphology of the exoskeleton suggests that it was likely to have been an active nektobenthic swimmer.

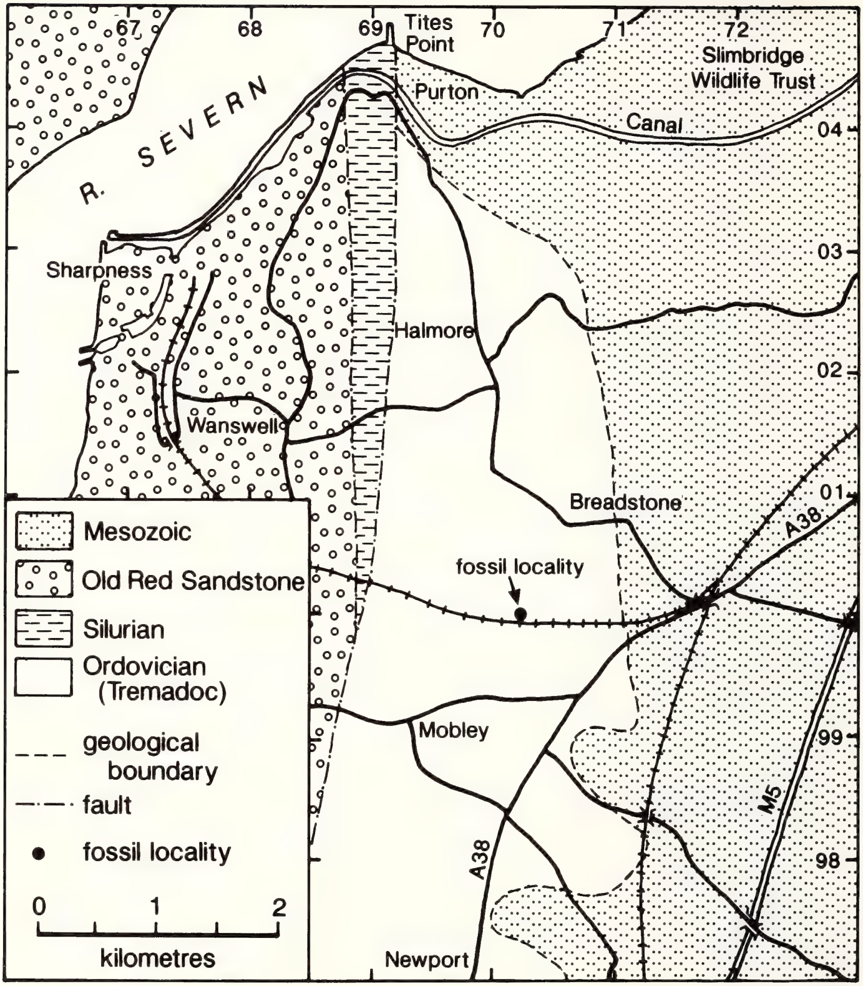
INTRODUCTION

Trilobites are often common fossils in rocks of early Ordovician (Tremadoc) age, and have been known from Wales for over 150 years. Although the early descriptions of such trilobites were based on the best material known at the time, it was often distorted or fragmentary. This applies especially to species described first from North Wales, where the argillaceous rocks have been subject to distortion so that the fossils are invariably stretched or squeezed. The palaeontologist is always trying to find better material of such species to gain an understanding of their real characteristics in an undistorted condition.

Early Ordovician (Tremadoc) rocks are exposed in the Bristol region in the Tortworth inlier (Curtis, 1968) (Figure 1). "Exposed" is perhaps an inappropriate word, because exposure at the surface is very poor. The rocks are for the most part soft greenish or grey shales, which weather rapidly, and in consequence produce low ground used for agriculture. From time to time, however, trenches have been dug through the shales, which have proved fossiliferous in places. Some of the trilobites recovered were described by Stubblefield (*in* Smith, 1938), and it was clear from this account that the trilobites from the Tortworth area did not suffer from the preservation problems that characterise the Tremadoc rocks of North Wales. Thanks to assiduous collecting by Dr M. L. K. Curtis, former Curator of Geology at Bristol City Museum & Art Gallery, there is a fine collection of Tremadoc trilobites from these temporary exposures.

Smith (1933) and Curtis (*in* Curtis *et al.*, 1955; 1968) distinguished two formations in the Tremadoc of Tortworth - the Breadstone Shales below, overlain by the Micklewood Beds, an altogether more sandy formation which still has some small exposures in Damery Quarry. The Breadstone Shales are similar in lithology, and contain an assemblage of fossils like that from the lower part of the Shineton Shales in Shropshire, where well-preserved trilobites have been known for more than a century.

The olenid trilobite *Beltella* has been the subject of much discussion in the literature. Oddly enough, the type species *B. depressa* (Salter) has not been fully described since Lake's (1919) account. The type material from North Wales is imperfectly preserved, and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Purton
Canal
04
R. SEVERN
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Sharpness
Halmore
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Wanswell
Breadstone
01
A38
fossil locality
Mobley
99
M5
A38
98
Newport
Mesozoic
Old Red Sandstone
Silurian
Ordovician (Tremadoc)
geological boundary
fault
fossil locality
0
1
2
kilometres

FIGURE 1. Geological map showing part of the outcrop of early Ordovician (Tremadoc) rocks in the Tortworth inlier, Gloucestershire. The locality of the trilobites illustrated here is a temporary water pipe trench 192m W 32°S of Crawless Old Barn, SSW of Breadstone (ST 7026 9997), where the specimens were collected by Dr M. L. K. Curtis in 1971.

the presence of this species in the Breadstone Shales (Stubblefield *in* Smith, 1933) indicated that a better idea of its morphology might be obtained from an examination of material from Gloucestershire. The authors are in the process of redescribing Tremadoc trilobites from Britain. The best preserved material of *B. depressa* is in Bristol City Museum & Art Gallery. Unlike material from elsewhere this retains much of its original relief. Some specimens required preparation to be freed of the enclosing matrix.

This paper evaluates the status of *Beltella* in the light of this material. We also take the opportunity to figure comparative material from Newfoundland in the collections of the Natural History Museum, London. We hope that its publication in this journal will encourage palaeontologists in the Bristol area to collect from temporary exposures in the Tortworth inlier whenever they are excavated in future.

SYSTEMATIC DESCRIPTION

Abbreviations. BRSMG, Bristol City Museum & Art Gallery; BGS, British Geological Survey, Keyworth; NHM, Natural History Museum, London; SM, Sedgwick Museum, Cambridge.

Terminology. The morphological terms used in the description below are illustrated on a reconstruction of *Beltella depressa* (Figure 2).

Family OLENIDAE Burmeister, 1843
Subfamily PELTURINAE Hawle & Corda, 1847
Genus *Beltella* Lake, 1919

1962 *Chunkingaspis* Lu, p. 43.

Type species. Ellipsocephalus depressus Salter *in* Murchison, 1859.

Beltella depressa (Salter *in* Murchison, 1859).

1859 *Ellipsocephalus depressus* Salter *in* Murchison, p. 47, Foss. 7, fig. 2.
1919 *Beltella depressa* (Salter); Lake, p. 104, pl. 12, figs 6-8.
1982 *Beltella depressa* (Salter); Rushton, p. 52, pl. 3, fig. 12.
1988 *Leptoplastides depressus* (Salter); Morris, p. 126 (with full synonymy).

Lectotype. Selected as 'type' by Lake (1919, explanation to pl. 12, fig. 6), BGS GSM10843, Lower Tremadoc Tyn-llan Beds, Penmorfa near Porthmadog, Gwynedd.

Material. In North Wales this species occurs at the type locality (e.g. BGS GSM10836, GSM10840, GSM51513; SM A901) and also in the *R. flabelliformis* biozone in the Ogof dd*d* section, Criccieth (see Rushton, 1982, text-fig. 2, p. 43). From the Breadstone Shales it has been reported from the Breadstone shaft (e.g. BGS GSM51526-28) and Crawless Old Barn, Breadstone (e.g. BRSMG Cc860a,b, Cc861a,b, Cc866, Cc2010, Cc2017, Cd550a,b; see Figure 1), and from a ditch on the S side of the road E of the Plough Inn, Mobley (see Smith, 1933, p. 361). *B. depressa* occurs also in the Clarenville Formation (Lower Tremadoc) of Random Island, Newfoundland (e.g. NHM It20102a,b, It20230).

Description. The type specimen is a thorax and pygidium. It is slightly distorted (Lake, 1919, pl. 12, fig. 6), but nonetheless shows unmistakable characters that link it with the material from the Breadstone Shales, notably the truncate posterior thoracic segments, and that it is the same species as the newly illustrated material is not in doubt.

This species could grow large for the subfamily Pelturinae - the longest specimens are nearly 10 cm long, which is about three times the size of a typical *Peltura* specimen. Most material is more or less flattened. The extent of this flattening is difficult to assess, but the best-preserved material from the Breadstone Shales (e.g. Plate 1A, B) retains

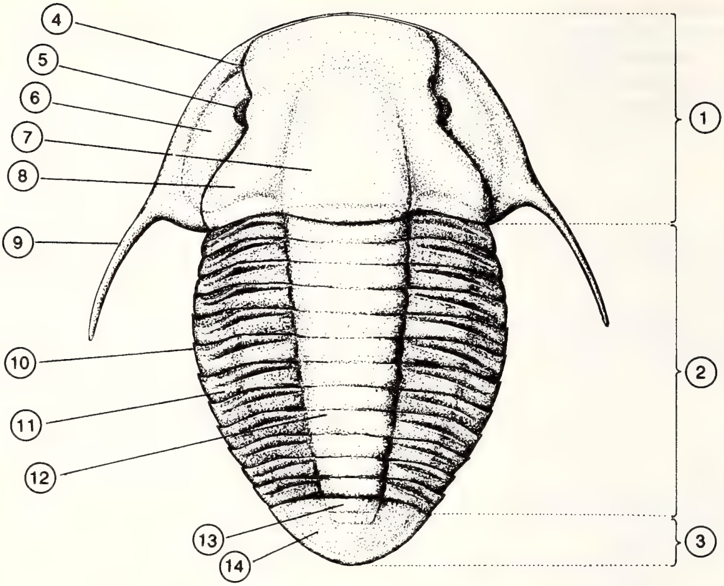


FIGURE 2. Reconstruction of *Beltella depressa* (Salter), with the principal parts of the exoskeleton identified: 1, cephalon; 2, thorax; 3, pygidium; 4, facial suture; 5, eye; 6, librigena (free cheek); 7, glabella; 8, fixigena (fixed cheek); 9, genal spine; 10, facet; 11, pleura; 12, thoracic axis; 13, pygidial axis; 14, pygidial pleural field. Not shown are the *hypostome*, which is an oval rigid plate lying underneath the glabella, and the *doublure*, the reflexed continuation of the dorsal exoskeleton as a rim onto the ventral side. *Sagittal* (abbreviated sag.) refers to measurements along the midline of the trilobite, from anterior to posterior; *exsagittal* (abbreviated exsag.) refers to measurements parallel to, but outside, the midline.

some relief. If we are correct in identifying the cranidium from the Micklewood Beds figured by Curtis (1968, pl. 9, fig. A as *Peltura olenoides*), which is in full relief, with *Beltella*, the original convexity was considerable. The effect of flattening alters several of the characters of the cephalon, if *Beltella* is like other olenids. For example, Fortey (1974) discussed the effects of flattening on *Bienvillia stikta*, and showed that it tended to emphasise the anteromedian point on the cranidium and also to increase the divergence on the anterior branch of the facial suture. It seems probable that such changes applied also in *Beltella depressa*, in which case in a dorsal view of an undistorted cranidium the anterior branches of the facial sutures may not have been very divergent. It is likely also that the preglabellar field sloped downwards, as it still does on the smaller specimens from the Breadstone Shales (e.g. Plate 1A). The glabella tapers gently forwards and is gently rounded to somewhat truncate in front. Again it is clear that in the unflattened state it is quite convex (trans.) The smaller specimens show a slightly more rounded glabellar front. Lateral glabellar furrows are not defined, but the occipital ring is usually visible, although the occipital furrow fades out before meeting the axial furrow. In the flattened condition the preglabellar field has about the same sagittal length as the occipital ring, but it would have appeared shorter in full relief. The anterior border of the cranidium widens towards the mid-line, and is poorly defined, at its widest a little narrower than the preglabellar field. The palpebral lobes are gently curved and rather small (about 10% of glabellar length), positioned in the typical pelturine place opposite the forward part of the glabella, and farther out than in some genera, such that the transverse width of the interocular cheek is about half that of the adjacent glabella. Eye ridges show up prominently on the comparatively unflattened small example (Plate 1A), but are subdued on larger specimens (e.g. Plate 1B, C). The posterior border furrows are wide and shallow, and slightly arched forwards.

On flattened material the anterior and posterior branches of the facial suture diverge outwards at similar angles; as noted above it is probable that flattening contributed something to the divergence of the anterior branch. The posterior branch curves adaxially at its distal end so that it ultimately cuts the border at an angle close to 90°. The anterior branch curves sharply adaxially where it meets the border, but probably remains supra-marginal, to meet the edge of the cephalon on the mid-line.

The free cheeks are wide, projecting well beyond the lateral edge of the thorax. Some of this may be accounted for by flattening. It is clear that the front of the cranidium was arched upwards, and the small cephalon on Plate 1A shows that the free cheeks continued the downward slope of the fixed cheeks. Hence it is likely that the whole cephalon was transversely convex, bowed upwards medially, and that originally the free cheeks sloped downwards more steeply than appears on the flattened material. Genal spines are present, not long, and extend back as the fourth or fifth thoracic segment. The border is ill-defined and widens towards the genal angle. The doublure underlies the border - hence it is somewhat narrower anteriorly.

The thorax has twelve segments, and is widest at the fourth or fifth segment, thereafter tapering backwards. Overall it has a convex-outward outline, and so differs from other olenids such as *Westergaardites*, in which the thorax tapers uniformly backwards. The posterior segment is only a little narrower (sag., exsag.) than the anterior ones, although its pleura is only about half as wide (trans.) as at the fifth segment. The axis tapers uniformly along the length of the thorax, at the last segment having about the same transverse width as the pleura. The pleural furrows are oblique, and quite deep. The most remarkable feature of the thorax concerns the change in the facets and pleurae terminations along its length. On the first segment the facet is very wide (exsag., tr.) and extends to a point of articulation quite close to the axis. The second segment is similar. On posterior segments the facets appear to be both narrower (exsag.) and steeper. On the last seven segments the anterior edge of the pleural tip is prolonged forward as a ridge, and the pleural tips are notably truncated. On these posterior segments the articulating half rings are not so wide.

The pygidium is about twice as wide as long. The axis is not clearly defined, especially posteriorly. Two axial rings are clearly visible, a third more obscure, the axis continuing the backward taper of the thorax. The surface of the pygidium carries many fine, raised ridges which run approximately parallel to its margin. Similar ridges are found on the truncate tips of the posterior thoracic segments, but otherwise the surface of the exoskeleton is smooth.

We have attempted to discover the hypostome by preparing through the dorsal surface of a complete cephalon, but were not successful. Many pelturines have small, natant (i.e. not suturally joined to the doublure) hypostomes (see, for example, Henningsmoen, 1957, pl. 26, fig. 2) and if this were the case in *Beltella* it would easily have become detached.

COMPARISONS AND DISCUSSION

Although material from the type locality is not well-preserved by comparison with the specimens from the Breadstone Shales, there are no differences of taxonomic significance. We also illustrate some specimens from Random Island in eastern Newfoundland, which was on the same (southern) side of the Iapetus Ocean as southern Britain during the Ordovician (see Figure 3). These have undergone similar flattening to the larger specimens from Gloucestershire shown on Plate 1, and appear to be identical apart from a somewhat more triangular pygidial outline. Specimens 6cm long are quite common amongst the Newfoundland material and the largest fragments in the collections of the Natural History Museum indicate that the species may have grown to more than 10cm long. A closely similar species from Argentina and Bolivia is *B. ulrichi* (Kayser) (see Harrington & Leanza, 1957), which possibly has a smaller, more transverse pygidium.

There has been discussion in the literature about the distinction (or otherwise) between *Beltella* and *Leptoplastides* Raw (type species: *L. salteri)*. Whitworth (1972), Nikolaisen & Henningsmoen (1985) and Morris (1988) regarded them as subjective synonyms. However, the type species of *Leptoplastides* carries distinctive mid-axial spines (Fortey & Owens, 1991) and the thorax does not have the peculiar structure we discussed above. In spite of a general similarity of the cephalic features, which are not particularly different from those of other pelturines, we believe the cited differences are enough to retain *Beltella* as a separate genus.

There has also been some discussion about which subfamily of Olenidae *Beltella* should be assigned to. Henningsmoen (1957) placed it in the Pelturinae; Tomczykowa (1968) in the Oleninae; Nikolaisen & Henningsmoen (1985) also preferred to assign it to Oleninae, emphasising that the glabellar shape of larger individuals was like that of other olenines. We think that more characters support *Beltella* as a pelturine, notably:

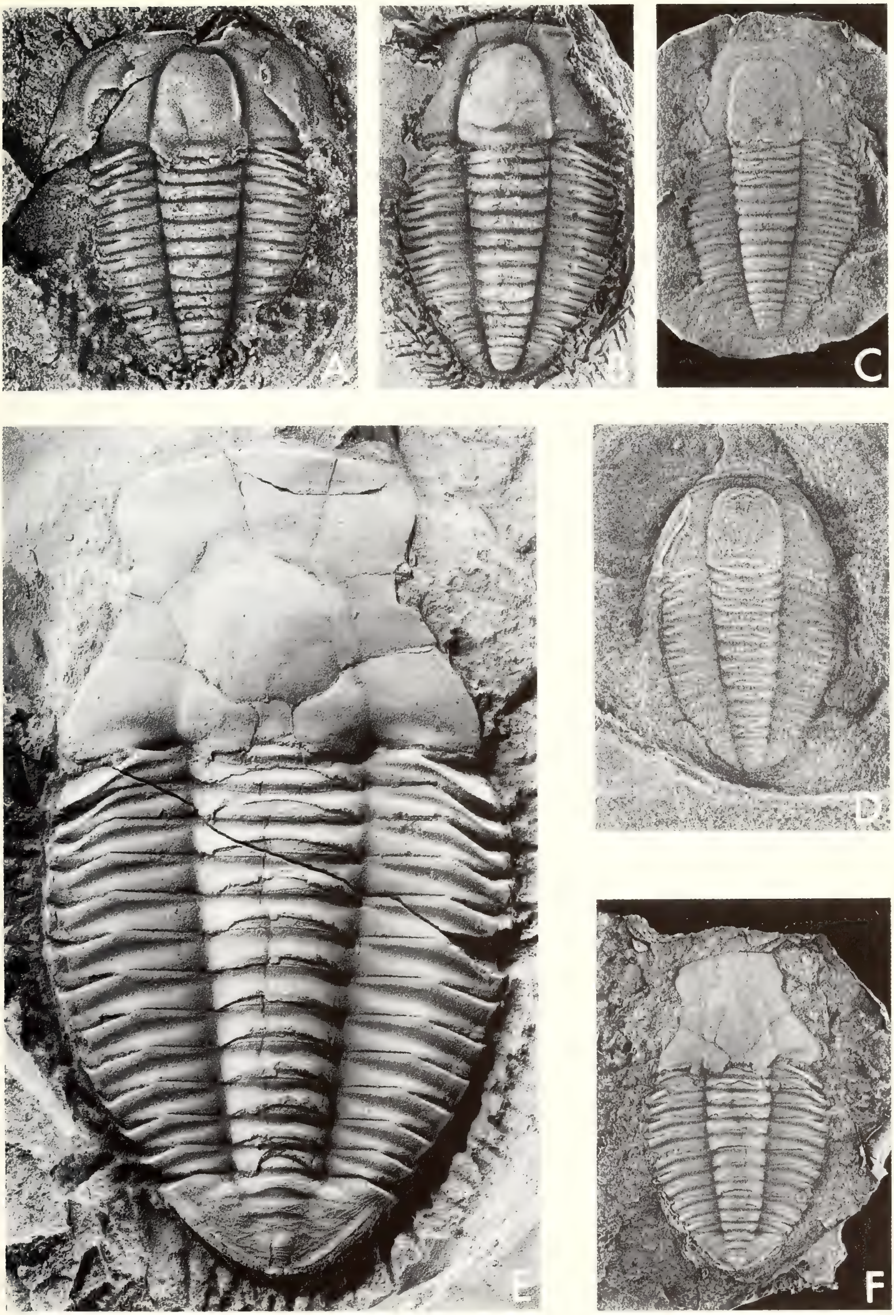
1, The dorsal raised lines on the pygidium. This peculiar sculpture is seen on nearly all advanced pelturines, but is not known in olenines.

2; The broadly arched anterior cephalic margin is like that of *Peltura* and *Peltocare* among pelturines. Olenines are not so strongly arched.

3, Olenine glabellas usually have a markedly different convexity from the adjacent fixed cheeks, so that the glabella is clearly differentiated in anterior view. In pelturines (at least those found in younger rocks than *Protopeltura*) the glabella and cheeks together comprise a broad arch about the midline, and the outline of the glabella does not interrupt this smooth curve. *Beltella* is like this.

4, The curious structure of the thorax on *Beltella* can be matched in another pelturine, *Acerocare* (see Henningsmoen 1957, pl. 30, fig. 9). This similarity even extends to having raised lines on the truncate pleural tips of the posterior thoracic segments.

PLATE 1 (opposite). *Beltella depressa* (Salter) from Gloucestershire (A-D) and from Random Island, Newfoundland (E, F). A, BRSMG Cd550a, × 3; B, BRSMG Cc860a, × 1·5; C, BRSMG Cc861a, × 1; D, BRSMG Cc2010, × 2; E, NHM It20230, × 2; F, NHM It20102b, × 1. C, D and F are latex casts made from external moulds. All specimens were whitened with ammonium chloride sublimate before photography.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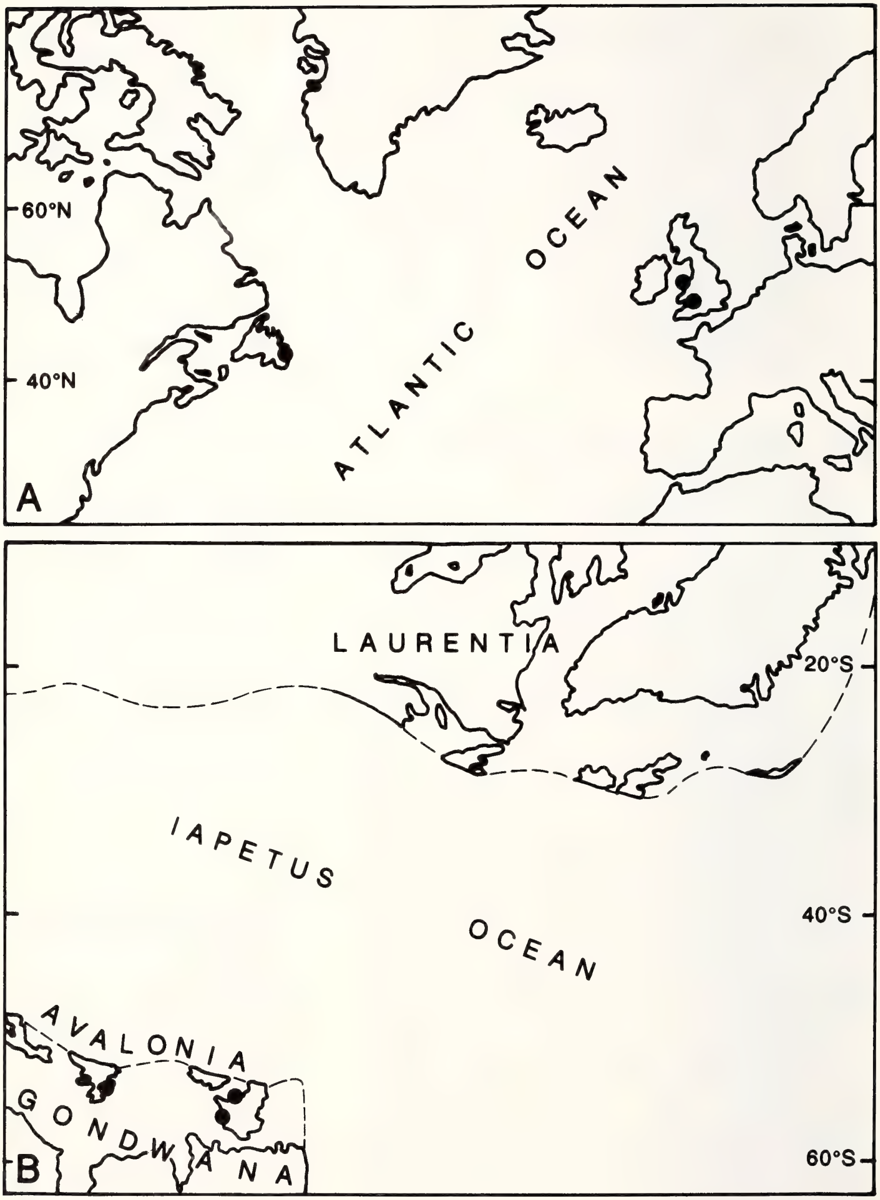
60°N
40°N
ATLANTIC OCEAN
A
LAURENTIA
20°S
IAPETUS OCEAN
40°S
AVALONIA
GONDWANA
60°S
B

FIGURE 3. Distribution of *Beltella depressa* in the British Isles and Newfoundland. A, present day geography; B, early Ordovician geography. In the latter, note the proximity of the occurrences in Avalonia, on the north-western edge of the Gondwanan continent.

For these reasons *Beltella* is assigned to the Subfamily Pelturinae here. We take a more restricted view of *Beltella* than did Tomczykowa (1968): only those species with posterior truncate thoracic pleurae are included. On cephalic features the genus *Chunkingaspis* Lu, 1962, from China is without doubt synonymous.

LIFE HABITS OF *BELTELLA*

Several peculiarities of the morphology of *Beltella* permit some comments on aspects of its life habits.

ENROLMENT

Most trilobites have facets along the length of the thorax which allow the distal parts of the thoracic segments to glide over one another during enrolment. This permits the enrolled trilobite to make a tight ball like a modern pill-bug. However, *Beltella* could not have enrolled in this way. The steep facets on the posterior segments indicate that some flexure between them was possible, but their truncate tips (with their lateral forward extensions) mean that this would have been limited, and could not have produced a tight ball. The very wide facets on the few anterior segments show that a lot of overgliding movement happened there. Did *Beltella* enrol at all? Or perhaps it had abandoned this mode of protection?

Note that the wide downsloping free cheeks prevent a close fit between the cephalon and pygidium - such as happened in the well-known trilobites *Calymene* and *Phacops*. The tapering thorax and pygidium have no correspondence in outline with the cephalic margin.

Hence if *Beltella* enrolled, most of the curvature would have been accommodated in the first few thoracic segments, the posterior part of the thorax being brought around and under the cephalic arch. Tight enrolment was not possible because of a poor match between cephalon and pygidium and the limited flexure of posterior thoracic segments. It seems quite plausible that *Beltella* did not enrol at all. The large amount of movement possible between the anterior thoracic segments might have been to aid the animal in moulting, to help it slough off the old exoskeleton; like many other arthropods trilobites moulted to accommodate size increases. Indeed, many trilobite fossils are moults rather than dead animals.

SWIMMING HABITS

The wide cephalon coupled with the broad cephalic vaulting of *Beltella* means that its wide cheeks probably hung down below the level of the rest of the exoskeleton. This is not, in general, a characteristic of benthic (bottom dwelling) trilobites. Species with this kind of morphology tend to be pelagic (Fortey, 1985). The same kind of truncate pleural tips have been described from such pelagic trilobites as *Carolinites*. However, *Beltella* differs from the typical pelagic trilobite in several regards: most important, the eyes are rather small, whereas they are frequently enormous (hypertrophic) in pelagic trilobites; also the elliptical outline of the thorax in *Beltella* is not so different from that of many 'normal' benthic trilobites. How can one plausibly account for such a combination of features?

The geological occurrence of olenid trilobites in general allows us to infer that they were specialised inhabitants of sea floors that were dysaerobic, i.e. low in oxygen. They are found in numbers only in rocks laid down in this rather unfavourable environment. Trilobites found with *Beltella* in Gloucestershire, North Wales and Newfoundland include the typical benthic olenid *Parabolinella*. This latter trilobite was probably rather sluggish, having little area for muscle insertion and numerous thoracic segments. The wide pleural regions were underlain by gill branches, and *Parabolinella* therefore had a large area available for absorbing what little oxygen was available. *Beltella* was altogether more convex, and with a smaller pleural area and consequently shorter gill branches. It seems possible that it responded to a critically low oxygen threshold by rapid escape, and active swimming. Its combination of characters, and the environment in which it lived, suggest that it was a nektobenthic animal, alighting briefly on the sea floor to feed before escaping to higher in the water column to replenish the oxygen in its tissues. It does not seem likely that *Beltella* migrated into the surface waters, for as far as we can ascertain, it is always found in association with other olenid trilobites, and therefore probably always stayed in the vicinity of the dysaerobic sea floor.

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PAST PRESIDENTS

WILLIAM SANDERS	1862
HENRY E. FRIPP	1876
GEORGE FORSTER BURDER	1880
JOHN BEDDOE	1883
Professor WILLIAM RAMSAY	1884
Rev. THOMAS HINCKS	1887
Professor C. LLOYD MORGAN	1890
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JAMES W. WHITE	1907
G. MUNRO SMITH	1910
Miss I. M. ROPER	1913
G. C. GRIFFITHS	1917
ERNEST (later Sir Ernest) H. COOK	1919
H. WOMERSLEY	1922
Professor O. V. DARBISHIRE	1924
JAMES RAFTER	1927
A. L. FLEMMING	1930
J. W. TUTCHER	1931
F. S. WALLIS	1933
Professor O. V. DARBISHIRE	1934
G. E. J. McMURTRIE	1935
Professor MACGREGOR SKENE	1938
H. TETLEY	1942
Sir LEWIS L. FERMOR	1945
F. W. EVENS	1948
H. H. DAVIS	1950
Professor W. F. WHITTARD	1952
J. H. SAVORY	1954
R. BASSINDALE	1956
Miss M. H. ROGERS	1958
F. COLES PHILLIPS	1960
H. H. DAVIS	1962
R. J. G. SAVAGE	1963
A. F. DEVONSHIRE	1965
F. R. STERNE	1966
R. BRADSHAW	1968
S. M. TAYLOR	1970
Mrs A. F. HOLLOWELL	1972
D. H. PEREGRINE	1974
D. HAMILTON	1976
J. F. W. McOMIE	1978
J. W. COWIE	1980
J. G. PRINCE	1982
V. DENNISON	1983
R. M. PAYNE	1985
T. E. THOMPSON	1987
Miss R. C. LEE	1989

MEMBERSHIP OF THE BRISTOL NATURALISTS' SOCIETY

The Society welcomes applications for membership from anyone interested in natural history. The annual subscription for full membership is currently £7.50: for members of the household of a full member the rate is £3.00. For those living outside a radius of 20 miles from Bristol city centre, a reduced rate of £5.00 applies. If you are aged between 18 and 21, associate membership is available at £6.00. The rate for juniors is £2.00. A prospectus which sets out the details and benefits of membership, and summarises the activities of the Society, may be obtained from the Hon. Treasurer:–

c/o CITY OF BRISTOL MUSEUM & ART GALLERY
QUEENS ROAD, BRISTOL BS8 1RL

PROCEEDINGS OF THE BRISTOL NATURALISTS' SOCIETY

The Society has stocks of back numbers of most annual parts of the *Proceedings* which may be purchased. In addition, a Centenary History of the Bristol Naturalists' Society, 1862–1962, being Part IIIA of *Proceedings*, 1962, price 25p postage extra, is still available. Application should be made to the Honorary Librarian, Bristol Naturalists' Society, at the above address.

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THE PROCEEDINGS OF THE BRISTOL
NATURALISTS' SOCIETY

VOLUME 50 (for 1990)

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EDITED BY P. R. CROWTHER

ASSISTED BY A COMMITTEE

"*Rerum cognoscere causas.*"—VIRGIL.

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Printed for the Society by Impress, Bedminster, Bristol

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Miss A. Heckels
Dr Gareth Jones
Dr M. H. Martin
Dr H. E. Rose
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VOLUME 50

CONTENTS

GENERAL & SECTIONAL PROCEEDINGS

Council, 1990 ii
Report of Council, 1990 iv
General Meetings, 1990 v
General Field Meetings, 1990 v
Report of the Botanical Section, 1990 vi
Report of the Geological Section, 1990 vii
Report of the Ornithological Section, 1990 vii
Statement of Accounts for the year ended 31 December 1990 viii
Report of the Entomological Section, 1990 x
Library Report, 1990 x
Past Presidents xii
Instructions to authors xiii

BRISTOL BIOTA

Avon & District Entomological Report, 1990 xiv
Avon Mammal Report, 1990 xxi
Bristol Botany in 1990 xxxi

ORIGINAL PAPERS - THE COAST OF AVON

Contents 1
Introduction and Acknowledgements 2
Geology of the Avon coast, by A. B. Hawkins .. 3
The post-glacial geology and geoarchaeology of the Avon wetlands, by J. R. L. Allen 28
A history of *Spartina* on the Avon coast, by M. H. Martin 47
The development and vegetational history of Berrow salt marsh, by A. J. Willis 57
The mudflat ecosystem and epipelic diatoms, by D. M. Paterson & G. J. C. Underwood 74
Animals of Severn Estuary salt marshes, by C. Little .. 83
Birds of the Avon shore, by H. E. Rose 95
Heavy metal pollution in the Severn Estuary, by M. H. Martin & C. L. Beckett 105

REPORT OF COUNCIL, 1990

Membership at the end of 1990 stood at 552, a welcome increase. At the Annual General Meeting on 20 January, Officers and Members of Council were elected, with Miss Rachel C. Lee as President. Council met seven times during the year.

The first three general lectures were again held on Saturday afternoons; this timing has proved popular and the practice will be continued.

Publication in 1988 of the Society's first special issue of its *Proceedings*, entitled *The Avon Gorge*, is to be followed by another in 1991, on *Bristol's Urban Ecology*.

The following planning or conservation proposals were received from local authorities for comment: Greater Bristol Nature Conservation Strategy, Ashton Court Estate Draft Management Plan and A Community Forest for Bristol. Copies, with the comments submitted, are in the Society's Library. Council members also made recommendations on practical aspects of the management of the Downs.

The Society is represented on the Severn Estuary Conservation Group, through which it has supported the publication of a new Severn Estuary conservation booklet. The Society continues to oppose the Cardiff Bay Barrage Bill, and has supported the Avon Wildlife Trust in its attempts to ensure that the proposed road connection from the M5 motorway to the Second Severn Crossing is so routed as to avoid disturbance to the Trust's Lawrence Weston Marsh Reserve. Members of Council are the current Chairmen of the Management Committees of Leigh Woods (National Trust) and of the Wetmoor woodland Reserve near Wickwar (Gloucestershire Trust for Nature Conservation).

The Hector Hockey Fund supported the following: the purchase of maps for fieldwork towards a pamphlet on *Trees in Clifton*; the publication of two papers in the *Proceedings*; and fencing to conserve rare woodland plants in Avon.

Council records the Society's grateful thanks to the relatives and friends of the late Mrs Joyce Kenney for donations in her memory which totalled £150. Council also thanks Bristol City Council's Director of Arts, Mr M. Heighton and Assistant Director of Arts (Museums & Art Gallery), Mrs H. Woolley, for the use of rooms for Council meetings and for meetings of the Botanical Section, as well as for the continued accommodation of the Society's Library within the City Museum.

We report with regret the deaths during 1990 of Mrs M. L. Baldwin, Mrs Marion Browne and Mr E. P. Stephens. The death on 1 January, 1990 of Dr T. E. Thompson, our immediate Past President, was recorded in the *Proceedings* for 1989. We also record belatedly the death on 21 March, 1986 of our Honorary Member Sir Maurice Yonge CBE, FRS, FRSE, the distinguished marine biologist, a member for 52 years. Born in 1900 and educated at Edinburgh University, he worked at the Plymouth Marine Laboratory from 1925 to 1933. He organized and led the Great Barrier Reef Expedition of 1929. While Professor of Zoology at the University of Bristol from 1933-1944 he inaugurated studies on the Bristol Channel which led to a notable series of papers in our *Proceedings*. He was Regius Professor of Zoology at Glasgow from 1944, retiring in 1964, and will probably be best known to present members as the author of two volumes in Collins' *New Naturalist* series: *The Sea Shore* (1949) and the monograph *Oysters* (1960).

SYLVIA KELLY, *Hon. Secretary.*

GENERAL & SECTIONAL PROCEEDINGS

GENERAL MEETINGS, 1990

20 Jan.	"Wildlife indoors", by Mr R. G. Symes.
10 Feb.	"Bats", by Dr G. Jones.
3 Mar.	"Wildlife of the Falkland Islands" (in association with Falklands Tourism), by Mr P. Morrison.
23 May	Annual Buffet Supper - "Think globally, act locally", by Mr C. F. W. Kendrick.
2 Oct.	"Wetlands flora", by Mr O. Mountford.
1 Nov.	"Spiders", by Mr F. Farr-Cox.
6 Dec.	"Dragonflies of south-west England", by Mr D. Smallshire.

SYLVIA KELLY, *Hon. Secretary.*

GENERAL FIELD MEETINGS, 1990

17 Feb.	Mr D. A. Cullen. Chew Valley Lake. Over thirty bird species were seen, though the mild weather meant the absence of large flocks of wintering duck. Some early spring flowers were noted.
24 Mar.	Miss M. Jervis. Severnside canals. A morning walk along Stroudwater and Sharpness canals, and a visit to Frampton Pools. An afternoon visit to Wallsworth Hall, home of the Society for Wildlife Art of the Nations, to view exhibitions which included the BBC's 'Wildlife Photographer of the Year'.
13 Apr.	Miss R. C. Lee. The Quantocks. After a bad forecast, a bright sunny day. A circular walk from Holford up to open moorland. Many woodland birds and spring flowers, and two groups of Red Deer were seen.
19 May	Miss S. Garden. Forest of Dean. In the morning, a visit to Nagshead Plantation for woodland flowers and birds. An afternoon walk along New Fancy Trail, past conifers and mixed woodland.
2 Jun.	Miss M. Jervis. Tewkesbury area. A morning walk in the Mythe Nature Reserve along the old railway. Spring flora included Narrow-leaved Pea and Gipsywort (not yet in flower). Afternoon in Tewkesbury.
19 Jun.	Mrs A. Hollowell. Brislington Brook. A fascinating evening walk to explore a relatively unknown green valley in the midst of suburbia. Many fine trees and a good selection of wayside flowers were noted. The party was undeterred by two very heavy downpours!
7 Jul.	Dr N. Malcolm and Dr J. Rees. Craig-y-llyn, Rhondda Valley, Wales. A first visit to an interesting habitat - two corrie lakes below towering north-facing screes - was marred by poor weather, but yielded many rushes, sedges and ferns, three species of willowherb and water lobelia.
8 Sep.	Mr D. A. Cullen. A visit to Portland Bill, Radipole Lake and Lodmore RSPB Reserve, to see autumn migration of birds.

13 Oct. Miss S. Garden. Symonds Yat Bird Park and Queenswood Arboretum, Herefordshire. An intersting collection of foreign birds, then a guided tour of 170 acres of fine woodland including many exotic trees.

3 Nov. Miss R. C. Lee. Durleigh Reservoir and the Quantocks. The year's final general field meeting, on a perfect autumn day. Geese, duck, waders and gulls were seen at Durleigh; two short walks on the Cothelstone and Lydiard Hills provided fine views, with good sightings of Buzzards.

RACHEL C. LEE, *Hon. Secretary, Field Committee.*

REPORT OF THE BOTANICAL SECTION, 1990

At the Annual General Meeting held on 25 January 1990 the following were elected: President - Mr R. M. Payne; Hon. Secretary & Treasurer, Mr A. L. Grenfell; Committee - Lady Rosemary Fitzgerald, Miss I. F. Gravestock, Mrs C. Kitchen, Mr M. A. R. Kitchen, Ms L. McDonnell, Dr N. Malcolm,. Mr P. J. M. Nethercott, Miss A. P. Pockson, Mr A. G. Smith and Mrs N. Vaughan Davies.

The following indoor meetings were held:

25 Jan. Annual General Meeting & Members' Evening.

22 Feb. "Photocall" - members' slides.

22 Mar. "Rare plants of south-west England", by Lady Rosemary Fitzgerald.

25 Oct. "Digitalis, Dandelion and Burdock", by Mrs M. Lindop, M.R.Pharm.S.

22 Nov. Members' Evening.

28 Dec. "Plants of the Cretan gorges", by Mr N. J. Turland.

The following field meetings took place, under the leadership of those shown:

4 Mar. Burrington Combe, for bryophytes, Mr Peter Martin.

22 Apr. Cotswolds & south Gloucestershire, Mr A. L. Grenfell.

20 May Mascall's Wood, Cheddar, Mr L. Cram.

29 May Winterbourne area, Mr A. L. Grenfell.

13 Jun. Glen Avon & Shirehampton Marshes, Mr A. C. Titchen.

23 Jun. Kenfig Burrows, Dr N. Malcolm & Dr J. Rees.

27 Jun. Clevedon coastal walk, Mrs Helen Titchen.

5 Jul. Netham - Crew's Hole - Trooper's Hill, Mr A. L. Grenfell & Mr P.J.M. Nethercott.

14 Jul. Oxford Botanic Garden, Mr P. J. M. Nethercott.

8 Aug. Assley Common (near Wickwar), Mr Mark & Mrs Clare Kitchen.

15 Aug. Cumberland Basin, Bristol, Mr A. L. Grenfell.

25 Aug. Eastwood Farm Open Space, Brislington, Mrs N. Vaughan Davies & Miss I. F. Gravestock.

16 Sep. Clifton and Durdham Downs, & Sneyd Park, Mr P. J. M. Nethercott.

18 Nov. Fungus foray at Walton Down, Somerset, Mr J. G. Keylock.

ADRIAN L. GRENFELL, *Hon. Secretary.*

REPORT OF THE GEOLOGICAL SECTION, 1990

At the Annual General Meeting held on 17 January 1990 the following were elected: President - Dr P. Hardy; Hon. Secretary /Acting Field Secretary - Dr P. R. Crowther; Hon. Treasurer - Mr D. A. Wilson; Committee - Mr S. Carpenter, Mr D. Cope, Mr M. Curtis, Mr V. Dennison, Mrs G. Hamilton, Mrs M. E. Poolman.

The following indoor meetings were held:

17 Jan. Annual General Meeting & Presidential Address - "Geology by the parish: Shapwick, a case study", by Dr Peter Hardy (University of Bristol).

21 Feb. "Origin of the dinosaurs", by Dr Michael J. Benton (University of Bristol).

21 Mar. "Cavemen, Caverns and Carnivores: Ice Age discoveries from Westbury-sub-Mendip", by Dr Michael A. Bishop (Plymouth City Museums).

17 Oct. "Flights of fancy: reconstructing the habits of pterosaurs", by Grant Hazlehurst (University of Bristol).

21 Nov. "An experimental view of how the earth works", by Dr Michael Carroll (University of Bristol).

12 Dec. Members' Evening.

The following field meetings were held, under the leadership of those shown:

17 Jun. Tedbury Camp and Vallis Vale, Mr C. J. T. Copp.

15 Jul. Callow Rocks Quarry, Mendip, Mr V. Dennison.

9 Sep. Charmouth, Dorset, Mr R. Edmonds (Warden, Charmouth Heritage Coast Centre).

PETER R. CROWTHER, *Hon. Secretary.*

REPORT OF THE ORNITHOLOGICAL SECTION, 1990

At the 66th Annual General Meeting held on 24 January the President, Mr S. M. Taylor and the Hon. Secretary and Treasurer, Mr T. G. Evans, were re-elected. Mr R. L. Bland and Mr G. Walker retired from the Committee by rotation, and Mr P. J. Chadwick and Mrs P. Woodbridge were elected. In view of his position as BTO Representative for Avon, Mr Bland was co-opted on to the Committee.

[*continued on p. x*

STATEMENT OF ACCOUNTS FOR THE YEAR ENDED 31 DECEMBER 1990

Income and Expenditure for the year

1989	Income	*1990*
3081	Members' subscriptions	3657
236	Income tax repayment	373
117	Donations	201
2277	Sales of Proceedings and grants	1076
111	Sales of books and journals	126
279	General field meetings and Supper	116
359	Bank interest	654
6460		6203
	Expenditure	
949	Printing and stationery	1063
590	Postage and telephone	548
1974	Proceedings and Bird Report	1950
1250	'Bristol's Urban Ecology'	65
104	Library, books	179
189	binding	30
301	subscriptions and journals	230
100	fire insurance	100
11	Donations	11
187	Indoor meetings	560
100	Grants to Sections	150
5755		4886
705	Surplus on year	1317
6460		6203

Balance Sheet at 31 December 1990

1989		*1990*
5000	Income Bonds (National Savings)	5000
609	National Savings Bank	1045
1575	Cash at bank – current accounts	666
4648	– interest account	8316
20	Prepayment	–
11852		15027
3372	Less creditors (subscriptions in advance 290; Proceedings and reprints for 1988, 2380; for 1989, 1464; room hire, 303)	4437
8480		10590
	Represented by:	
158	Harry Savory Illustrations Fund	283
33	Conservation Appeal	165
5649	Hector Hockey Memorial Fund	6045
490	R.G. Williams Memorial Fund	630
2150	General Fund at 31 Dec. 1989: 2150	
	Add surplus on year: 1317	3467
8480		10590

SPECIAL FUNDS

Receipts and Payments, year to 31 December

1989		*1990*
	Harry Savory Illustrations Fund	
158	Fund at 31 December 1989	158
	Donations to fund during 1990	125
158		283
	Conservation Appeal	
33	Fund at 31 December 1989	33
	Donations to Appeal in 1990	132
33		165
	Hector Hockey Memorial Fund	
5649	Fund at 31 December 1989	5649
	Year's investment income	696
	Less one grant made	(300)
5649		6045
	R.G. Williams Memorial Fund	
490	Fund at 31 December 1989	490
	In memory of Mrs V. J. Kenney	140
490		630

NOTES TO THE ACCOUNTS

(1) No value is placed upon the contents of the Library and stocks of periodicals.

(2) These accounts do not record any balances held by sectional treasurers or the Ornithological Section's Special Fund of £588.

(3) The Hector Hockey Fund is represented by the Income Bonds and National Savings Bank.

P. J. M. NETHERCOTT
Hon. Treasurer
30 September 1991

T. B. SILCOCKS
Hon. Auditor
4 November 1991

The following indoor meetings were held:

24 Jan.	Annual General Meeting and Presidential Address - "Of shoes and ships and sealing wax: reflections on some European habitats", by Mr S. M. Taylor.
23 Feb.	"Bird Habitats in Hampshire and Dorset", by Dr G. Green.
23 Mar.	"Greenland White-fronted Geese", by Dr A. Fox.
10 Oct.	Video evening: video films of Osprey and Short-eared Owl.
9 Nov.	"Bird studies by the River Stour", by Dr G. Green.
7 Dec.	"Birds of Gloucestershire", by Mr T. Jones.

Eighteen field meetings were held, which again included a River Exe cruise (marred, however, by gales and driving rain). Other destinations included Tregaron, Exmoor and a visit to Llanelli to see preparations for a new Wildfowl and Wetlands Trust reserve.

The Section continued with a number of surveys: Birds of Estuaries Enquiry, the River Severn Low Tide Survey, the BTO's National Atlas of Breeding Birds project, Birds in Gardens, overwintering warblers and a county Rookery census.

The Section Committee met six times. It was a disappointing year for attendance at lectures: we hope for a better response to our efforts in 1991.

TREVOR G. EVANS, *Hon. Secretary.*

REPORT OF THE ENTOMOLOGICAL SECTION, 1990

With the Section still in suspended animation through lack of support, Mr G. Best has continued as Acting Hon. Secretary, and Council took steps to include two lectures of Entomological interest in the Society's programme of General Meetings. Three field meetings were held, under the leadership of those shown:

6 May	Almondsbury Hill, Mr G. Best. Ladybirds and other insects.
16 Jun.	Leigh Woods, Mr R. J. Barnett. General entomology in afternoon and light-trapping in evening (joint meeting with Royal Entomological Society of London (West Region) and British Entomological and Natural History Society).
29 Jun.	Old Down Hill, Mr G. Best. Glow-worms.

GRAHAM BEST, *Acting Hon. Secretary.*

LIBRARY REPORT, 1990

The post of Hon. Librarian has remained vacant. The Committee did receive a welcome offer of help from a qualified librarian, who was able to obtain for us some very useful advice on cataloguing systems for specialist libraries, but she had to withdraw her support from the Library after a short time because of a change in work commitments. Committee members have continued to carry out routine work in the Library and to adapt the methods used so that they are now more straightforward and effective.

The Library opening hours of Wednesdays 1.15 - 1.45 pm and Saturdays 10.15 am - 12 noon have been maintained. During the year 208 visits were made by 32 members, who borrowed 232 items. Visits by Museum and Art Gallery staff totalled 47. This year five books have been purchased. Currently sixteen journals (including reports and other serials) are received on subscription and 47 by exchange. The level of donations to the Library this year has been particularly gratifying. Eighteen books, 29 reports and 87 journal issues have been given, for which we are indebted to Mr P. J. M. Nethercott, Mr D. A. Wilson, Mr R. G. Symes, Mr S. M. Taylor, Mr S. C. Carpenter, Dr H. Gorvett, Mr C. H. Cummins, Dr J. F. W. McOmie, Mr L. Jones, Mrs A. J. Hollowell, the Bournemouth Natural Science Society and the Smithsonian Institution. Four audio tapes of wildlife sounds have also been donated; these represent the start of an initiative to set up a collection of sound recordings and video tapes for members' private use. The draft planning documents and the Society's comments on them, referred to in the Report of Council, are available in the Library for consultation.

We express the Society's gratitude to Mr M. Heighton (Director of Arts, Bristol City Council) and Mrs H. Woolley (Assistant Director of Arts, Museums and Art Gallery) for the continuing use of the Library Room during the year.

ANNE F. HOLLOWELL, *Chairman, Library Committee.*

PAST PRESIDENTS

WILLIAM SANDERS	1862
HENRY E. FRIPP	1876
GEORGE FORSTER BURDER	1880
JOHN BEDDOE	1883
Professor WILLIAM RAMSAY	1884
Rev. THOMAS HINCKS	1887
Professor C. LLOYD MORGAN	1890
Professor ADOLPH LEIPNER	1893
Professor SYDNEY YOUNG	1894
S. H. SWAYNE	1897
Professor C. LLOYD MORGAN	1899
ARTHUR B. PROWSE	1901
C. K. RUDGE	1904
JAMES W. WHITE	1907
G. MUNRO SMITH	1910
Miss I. M. ROPER	1913
G. C. GRIFFITHS	1917
ERNEST (later Sir Ernest) H. COOK	1919
H. WOMERSLEY	1922
Professor O. V. DARBISHIRE	1924
JAMES RAFTER	1927
A. L. FLEMMING	1930
J. W. TUTCHER	1931
F. S. WALLIS	1933
Professor O. V. DARBISHIRE	1934
G. E. J. McMURTRIE	1935
Professor MACGREGOR SKENE	1938
H. TETLEY	1942
Sir LEWIS L. FERMOR	1945
F. W. EVENS	1948
H. H. DAVIS	1950
Professor W. F. WHITTARD	1952
J. H. SAVORY	1954
R. BASSINDALE	1956
Miss M. H. ROGERS	1958
F. COLES PHILLIPS	1960
H. H. DAVIS	1962
R. J. G. SAVAGE	1963
A. F. DEVONSHIRE	1965
F. R. STERNE	1966
R. BRADSHAW	1968
S. M. TAYLOR	1970
Mrs A. F. HOLLOWELL	1972
D. H. PEREGRINE	1974
D. HAMILTON	1976
J. F. W. McOMIE	1978
J. W. COWIE	1980
J. G. PRINCE	1982
V. DENNISON	1983
R. M. PAYNE	1985
T. E. THOMPSON	1987
Miss R. C. LEE	1989

INSTRUCTIONS TO AUTHORS

1) The editor welcomes original papers on the natural history of Avon and surrounding areas for consideration for publication in the *Proceedings*. Inexperienced authors may obtain advice from members of the Publications Committee. Authors should bear in mind that their readers will not usually be specialists in the particular subject, and that unnecessarily technical language can be a barrier to understanding.

2) All items for consideration should reach the editor by the end of February in each year. If there is likely to be a problem with this target date, please contact the editor in advance.

3) Manuscripts should be double-spaced, with wide margins, and on one side of the paper only. The author should retain a copy.

4) The writing should follow the style and format of the *Proceedings*. Abbreviations should not normally be used, especially in the references. An abstract should be supplied, and the text should be broken up by appropriate headings and sub-headings and accompanied by relevant illustrations. Captions to illustrations should be given separately at the end of the text.

5) Originals, not copies, of photographs, slides, line drawings, diagrams and maps should be submitted - they will be returned on request. Drawings and other diagrams should be not more than twice final size, and made in black medium. Photographs and slides may be submitted as prints, positives or negatives, preferably in monochrome. Graphs, charts and simple diagrams may most readily be produced by computer graphics; advice and help with this are available.

6) References should be listed at the end of the text in alphabetical order of the principal author's name, and should take the following form.

   Book AUTHOR (DATE). *Title*. Place of publication. Publisher.

   e.g. RACKHAM, O. (1986). *The history of the countryside*. London, J. M. Dent.

   Paper AUTHOR (DATE). Title. *Journal name*, volume, part, page numbers.

   e.g. ROSS, S. M. & HEATHWAITE, A. L. (1986). West Sedgemoor: its peat stratigraphy and peat chemistry. *Proceedings of the Bristol Naturalists' Society*, **44**, 19-25.

7) It is very helpful if the text can also be submitted on a magnetic disk readable under MS-DOS (any version), either as an ASCII ("text" or "print" file) or as a file produced by *Ability Plus*, *Galaxy*, *Word*, *Word Perfect* or *Wordstar* software. For other formats, please enquire. A disk version is especially valuable when many scientific names or specialised terms are involved.

8) The copyright of all published material will belong to Bristol Naturalists' Society, whose Council may authorise reproduction.

9) Twenty-five free reprints (without covers) of each paper will be supplied (to be shared among multiple authors). More may be ordered, at 25 pence per copy, at the time of submission

Proceedings of the Bristol Naturalists' Society (1990), **50**: xiv-xx

AVON & DISTRICT ENTOMOLOGICAL REPORT, 1990

compiled by R. J. BARNETT

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INTRODUCTION

Enthusiastic and co-ordinated study of our insect fauna appeared to be lacking again during 1990. However, attendance at the Society's two General Meetings devoted to invertebrates and at the three field meetings organised by the Entomological Section revealed a considerable number of interested bystanders. In neighbouring areas the most significant events were: the formation of the Somerset Moth Group, affiliated to the Somerset Trust for Nature Conservation; and the undertaking by Dr A. Duff, of 4 Amberley Close, Keinton Mandeville, Somerton, Somerset of the task of updating Wilson's (1958) list of the "Coleoptera of Somerset". The recording area taken by the Somerset Moth Group is that of present-day Somerset. This overlaps with the vice-county recording units covered in this report, which are in line with the Bristol/Avon Regional Environmental Records Centre. Dr Duff is maintaining continuity with Wilson by covering both the vice-counties that formerly made up Somerset, and hence is including south Avon; he would be very pleased to receive beetle records from the area.

I am very grateful to Mr A. H. Weeks for providing the climatological notes. No weather report appeared for 1989, so a Weather Synopsis is included here, together with that for 1990, based on data compiled from records of a climatological station at Yatton. The long-term biennial temperature pattern of odd-numbered years tending to excel even-numbered ones has been upset in recent times by pairs of "good" years: 1975-1976 (the most notable), 1983-1984 and now 1989-1990. The mean annual temperature for the decade 1981-1990 was 10·6°C, and the warmest years were 1982 (10·9°C), 1983 (11·0°C), 1984 (10·8°C), 1988 (10·7°C), 1989 (11·5°C) and 1990 (11·7°C). The last pair resembled 1975-1976 in producing a severe drought. More observers and more insect records would enable potential correlations between population levels and our variable weather to be noted.

Mr Weeks has also commented upon the status of butterflies during 1989. He reports that it was a good year for butterflies although the warm spring and then prolonged dry conditions produced early but short-lived broods. The Red Admiral appeared in early April, suggesting that some may have over-wintered, but the most interesting event was the success of blues such as the Common Blue, Brown Argus, Holly Blue, Chalkhill Blue and, in particular, the Small Copper. There is some suggestion that bird predators of the larvae, especially titmice, attempted to raise broods very early in the year, before the larvae were accessible. As a consequence, many nests failed but when the butterfly larvae did appear they were able to exploit lower levels of predation and build up good numbers.

In 1990 many insects had early seasons again, e.g. the Orange-tip butterfly. The Holly Blue had another excellent year, being especially abundant in town and city. Early October brought an influx of migrant moths, the most spectacular being the Crimson Speckled. Species that benefited from the hot summer of 1990 included the green shieldbug *Palomena prasina*, which was common in suburban gardens.

ENTOMOLOGICAL REPORT, 1990

The richness of the insect fauna in the Bristol district is emphasised in this report because, despite the very small number of records submitted for 1990, four of the species listed are included in the *British Red Data Book* (Large Marsh Grasshopper - RDB2, vulnerable; Silky Wave moth, Great Silver Diving beetle and the click beetle *Dirhagus pygmaeus* - RDB3, rare) and fifteen are of very local occurrence nationally.

Records of insects for 1990 were provided by: R. Angles (RA), R. J. Barnett (RJB), P. J. Chadwick (PJC), Chew Valley Ringing Station *per* R. Kersley (CVRS), R. S. Cropper (RSC), K. H. Poole (KHP) and A. H. Weeks (AHW). I have singled out the more interesting and/or localised species for mention in this report.

Scientific nomenclature follows these checklists: Lepidoptera - Bradley *et al.* (1972), Bradley & Fletcher (1979), Skinner (1984), Agassiz (1987); Orthoptera and Hemiptera - Potts (1964); Hymenoptera - Fitton *et al.* (1978); Diptera - Smith (1976); Coleoptera - Pope (1977).

TABLE 1. Monthly and seasonal trends in climate during 1989.

	Monthly differences			*Seasonal differences*	
	Max. T°	*% Rain*	*% Sun*	*Max. T°*	*% Rain*
Dec.	+1·5	22	65		
Jan.	+3·3	66	125		
Feb.	+3·3	184	155	+2·6	70
Mar.	+2·1	114	95		
Apr.	−1·9	195	90		
May	+3·7	22	145	+1·3	98
June	+1·4	57	125		
July	+3·0	100	150		
Aug.	+1·5	59	135	+2·0	69
Sep.	+0·9	55	96		
Oct.	+1·4	94	83		
Nov.	+0·2	69	98	+0·8	74

WEATHER SYNOPSIS, 1989

Locally1989 was the warmest year since 1949 and the sunniest since 1959. Table 1 shows the monthly and seasonal trends. Hardly a month was near normal: the most significant features are listed below.

January	exceptionally warm, dry and sunny. Only five air frosts and eight ground frosts.
February	exceptionally warm, but very wet. Sunshine again well above average. Only five air frosts and nine ground frosts; snow seen on one day (none accumulated).
March	very warm, rather wet.
April	rather cool, very wet (sixteen rain days). Seven air frosts and ten ground frosts (more than in any preceding month). Snow fell on two days.

May	warm, exceptionally dry and sunny. Rain fell on only four days.
July	warm and sunny. Only four rain days but average total; 70% fell on the 7th.
August	thirteen rain days, nevertheless dry. One-third of the month's rain fell on the 14th.
September	again dry. Rain fell on only eight days, 45% on the 16th.

Temperatures exceeded 80°F (26·6°C) in May, June, July and August, and reached 85·1°F (29·5°C) in June and 89·2°F (31·7°C) in July. Rainfall in the calendar year 1989 amounted to 796 mm, 90% of the ten-year average. The very dry autumn (see Table 1) was followed by one of the wettest winters on record (see Table 2). It was the third successive winter with no lying snow at the station.

TABLE 2. Monthly and seasonal trends in climate during 1990.

	Monthly differences			*Seasonal differences*	
	Max. T°	*% Rain*	*% Sun*	*Max. T°*	*% Rain*
Dec.	−0·7	130	48		
Jan.	+3·5	146	90		
Feb.	+3·9	213	120	+2·2	152
Mar.	+3·0	20	120		
Apr.	+0·7	58	125		
May	+3·4	12	153	+2·4	26
June	−1·4	126	70		
July	+1·8	77	150		
Aug.	+2·4	70	115	+1·1	89
Sep.	+0·3	113	130		
Oct.	+1·5	84	94		
Nov.	−0·1	67	115	+0·5	87

WEATHER SYNOPSIS, 1990

Temperature and sunshine records were similar to those for 1989. The 1990 total rainfall was 744 mm, 84% of the ten-year average; the spring months of March to May were particularly dry and yielded only 49·7 mm (26% of spring average), thus offsetting the gains made during the very wet winter. Table 2 shows the monthly and seasonal trends. Notable features of the months are listed below.

January	only two air frosts and eight ground frosts, a very low incidence.
February	only one ground frost - exceptional
April	six air frosts and eleven ground frosts (as in 1989, more than in any winter month).
June	disappointing; wet and cold.
August	opened with four very hot days; maximum of 34·8°C (nearly 95°F) on the 3rd.
September	a local deluge overnight on 22nd-23rd yielded 51·6 mm; a thundery cell appears to have followed the Congresbury Yeo river from north-west to south-east.

SPECIES OF NOTE IN 1990

LEPIDOPTERA (butterflies)

Dingy Skipper *Erynnis tages* (L.) Cleaves Wood ST7557 25 April (RJB); Crook Peak ST35 27 May (RA).

Grizzled Skipper *Pyrgus malvae* (L.) Cheddar Wood ST4455 5 May (RSC); Crook Peak ST35 6 May to 27 May (RA).

The Brimstone *Gonepteryx rhamni* (L.) First sightings: Leigh Woods ST5573 12 March (RJB); Yatton ST437655 12 March (AHW).

Orange-tip *Anthocharis cardamines* (L.) A very early season. First sightings: Banwell Hill ST3858 31 March (RSC); Wotton-under-Edge ST7593 31 March (RJB). Last sightings: Sand Bay ST36 24 May (RA); Tormarton ST7880 24 May (PJC).

Green Hairstreak *Callophrys rubi* (L.) Crook Peak ST35 27 May (RA).

Small Blue *Cupido minimus (Fuess.)* Aust ST5789 18 August (PJC); Blagdon Reservoir ST5258 22 August (PJC).

Brown Argus *Aricia agestis* (D. & S.) Sand Point ST36 2 May (RA); Gordano Valley NNR ST4373 26 July (RJB); Draycott Sleights ST486515 12 August (AHW); Crook Peak ST35 12 August (RA); Sand Point ST36 27 September (RA).

Chalkhill Blue *Lysandra coridon* (Poda) Uphill ST35 31 July to 12 August (RA); Draycott Sleights ST486515 12 August (AHW).

Holly Blue *Celastrina argiolus* (L.) Very abundant in both spring and summer; first and last dates given for each brood: 12 March to 30 May Yatton ST437655 (AHW); 6 July Yatton ST437655 (AHW) to 27 August Clevedon ST3970 (RSC). Also Sand Point ST36 1 October (RA).

Red Admiral *Vanessa atalanta* (L.) Spring sightings at Yatton ST437655 17 March, 4 April; many seen at this locality 2 July to 31 October (AHW); Sand Bay ST36 11 November (RA).

Painted Lady *Cynthia cardui* (L.) Sand Point ST36 9 June (RA); seen at Yatton ST437655 on 23 June and from 10 August to 12 October (AHW); Weston-super-Mare ST36 3 November (RA).

Small Pearl-bordered Fritillary *Boloria selene* (D. & S.) Crook Peak ST35 13 May to 19 July (RA); Charterhouse ST5056/5057 27 June (*per* AHW).

Dark Green Fritillary *Argynnis aglaja* (L.) Crook Peak ST35 19 July to 27 August (RA); Walton Down ST4273 20 July (RJB); Draycott Sleights ST486515 12 August (AHW).

Silver-washed Fritillary *A. paphia* (L.) Brockley Combe ST4766 17 July (RJB).

Glanville Fritillary *Melitaea cinxia* (L.) Sand Point ST3165 6 May "flying in good numbers" at this site of introduction (RSC).

The Grayling *Hipparchia semele* (L.) Uphill ST35 13 July to 12 August (RA); Walton Down ST4273 20 July (RJB); Gordano Valley NNR ST4373 26 July (RJB); Draycott Sleights ST486515 12 August (AHW).

LEPIDOPTERA ('macro'-moths)

Silky Wave *Idaea dilutaria* (Hb.) Durdham Down ST5673 12 July, one of its two British localities (Messrs Smith of Trowbridge, *per* RJB).

Blomer's Rivulet *Discoloxia blomeri* (Curt.) Leigh Woods NNR ST5573 16 June, to light (RJB *et al.*).

Little Thorn *Cepphis advenaria* (Hb.) Leigh Woods ST5573 17 May, flying by day (RJB).

Bordered Beauty *Epione repandaria* (Hufn.) Chew Valley Lake ST5559 no date (CVRS).

Mottled Beauty *Alcis repandata* (L.) extreme ab. *conversaria* (Hb.) Leigh Woods NNR ST5573 16 June, to light (RJB *et al.*).

Pale Oak Beauty *Serraca punctinalis* (Scop.) Chew Valley Lake ST5559 no date (CVRS).

Brindled White-spot *Ectropis extersaria* (Hb.) Leigh Woods NNR ST5573 16 June, to light (RJB *et al.*).

Convolvulus Hawk-moth *Agrius convolvuli* (L.) Alveston ST68 3 October, brought in by cat (Mr Constable *per* RJB).

Death's Head Hawk-moth *Acherontia atropos* (L.) Westbury-sub-Mendip ST54 11 October, larva and pupa (Mr Goady *per* RJB). Portishead ST47 6 October, live imago (Mrs Humphreys *per* RJB).

Humming-bird Hawk-moth *Macroglossum stellatarum* (L.) Marshfield ST7773 15 October (Mr Pitts *per* RJB).

Chocolate-tip *Clostera curtula* (L.) Chew Valley Lake ST5559 no date (CVRS).

Crimson Speckled *Utetheisa pulchella* (L.) Brean Down ST2958 7 October, "one flying near path up south side" (RSC *per* KHP).

Scarlet Tiger *Callimorpha dominula* (L.) Leigh Woods ST5573 10 April and 17 May, larvae on bramble (RJB); Gordano Valley NNR ST4373 8 July, imago (RJB).

Brindled Green *Dryobotodes eremita* (Fabr.) Chew Valley Lake ST5559 no date (CVRS)

Grey Chi *Antitype chi* (L.) Chew Valley Lake ST5559 no date (CVRS).

Small Purple-barred *Phytometra viridaria* (Cl.) Cleaves Wood ST7557 25 April (RJB).

LEPIDOPTERA ('micro'-moths)

Micropterix tunbergella (Fabr.) Durdham Down ST564736 24 April (RJB); Leigh Woods ST5573 2 and 17 May, very common (RJB); Ashton Court ST5571 4 May (RJB).

Psychoides filicivora (Meyr.) Leigh Woods ST5573 13 June, swept (RJB).

Glyphipteryx linneella (Cl.) Brockley Combe ST4766 17 July, swept from base of *Tilia* (RJB).

Light Brown Apple Moth *Epiphyas postvittana* (Walk.) Filton ST609797 23 April, to light, first known record for v.c. 34, W. Glos. (Mr A. Pym *per* RJB); Bishopston ST5875 15 September to 17 October, common at light (RJB).

Pyrausta nigrata (Scop.) Walton Down ST4273 20 July (RJB).

ORTHOPTERA (grasshoppers and crickets)

Grey Bush-cricket *Platycleis albopunctata* (Goeze) Brean Down ST2858/2958 2 September, "first found here 1974, recorded annually ever since" (RSC).

Slender Groundhopper *Tetrix subulata* (L.) Gordano Valley NNR ST4373 10 May (RJB); Windsor Hill ST6145 7 October (RSC).

Large Marsh Grasshopper *Stethophyma grossum* (L.) In its Somerset Levels locality ST44 11 August, also seen in 1989 (RSC).

HEMIPTERA, HETEROPTERA (true bugs)

Palomena prasina (L.) Common this year. Durdham Down ST564736 24 April (RJB); Leigh Woods ST5573 16 June (RJB); Gordano Valley NNR ST4373 21 June (imagines), 26 July (nymphs) (RJB); Ashton Court ST5571 30 July, ST5672 1 August (RJB).

HYMENOPTERA, SYMPHYTA (sawflies)

Sirex noctilio (Fabr.) In a Kingswood, Bristol bakery ST67 14 November (Environmental Health Department, Kingswood District Council, *per* RJB).

DIPTERA (flies)

Anomoia purmunda (Harris) Bishopston, Bristol ST5875 30 August (RJB).

COLEOPTERA (beetles)

Nebria complanata (L.) One seen at its Berrow locality ST2951 28 July (RSC).

Laemostenus terricola (Herbst.) Gough's Old Cave, Cheddar ST4653 20 October, several in bat droppings (RSC); Draycott Cave ST4851 18 November, two associated with rabbit droppings (RSC).

Great Silver Diving Beetle *Hydrophilus piceus* (L.) Burnham-on-Sea ST300513 1 March, attracted to house light (Mr Blackwell *per* RJB).

Cantharis fusca (L.) Leigh Woods ST5573 17 May, swept (RJB); Walton Down ST4273 20 July, swept (RJB).

Cteniopus sulphureus (L.) Brean Down ST2958 15 July, "very abundant" (RSC).

Oncomera femorata (Fabr.) Leigh Woods ST5573 17 May, under stones (RJB).

Wharf-borer *Nacerdes melanura* (L.) Bristol Industrial Museum ST5872 June, several (RJB).

Stenostola dubia (Laich.) Leigh Woods ST5573 2 and 17 May, swept from low branches of *Tilia*, first known record for v.c. 6, N. Somerset (RJB).

Pseudocistela ceramboides (L.) Leigh Woods ST5573 16 June, to light (RJB).

Dirhagus pygmaeus (Fabr.) Brockley Combe ST4766 17 July, swept, second known record for "Somerset" v.c 5 and 6 (RJB).

Orange Ladybird *Halyzia 16-guttata* (L.) Brockley Combe ST4766 17 July (RJB).

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AVON MAMMAL REPORT, 1990

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INTRODUCTION

This is the second recent Mammal Report for Avon, the previous year's (Symes & Trump, 1991) being an initial attempt to re-kindle interest in mammals in Avon. That report met with favourable comment and support, and it is hoped that further information on the activity in Avon regarding wild mammals will stimulate others. Interest in wild mammals in Avon clearly involves the professionals -, for example, in the form of researchers at the University, as scientists in ADAS and English Nature, as pest controllers, and as veterinarians - and it also involves many amateurs whose interests range from making field observations and recording, to attempting to protect threatened species or habitats, to care and rehabilitation, and to various field sports. This Avon Mammal Report for 1990 aims to serve as a register of that interest and involvement with wild mammals.

REPORTS ON MAMMALS

INSECTIVORA (hedgehogs and moles)

Hedgehog *Erinaceus europaeus*. Marion and Mike Nairn of Yate were reported (*Bristol Mercury*, 15 November 1990) to be rearing over 100 juvenile hedgehogs as part of their Adopt-a-Hog project, seeking to release them back into the wild later. Hilary Sperring of Portishead also reared early orphaned hedgehogs and released them back into the wild successfully. She reported that she had many telephone calls about abandoned young, perhaps where female adults had been killed on the road, and was particularly concerned about the numbers of the general public who seemed eager to attempt to rear hedgehogs, but who were clearly unaware of the problems involved and the dietary requirements. The costs involved in rescuing orphaned hedgehogs are clearly high, and rescuers do not receive financial sponsorship.

The Mammal Society organised a hedgehog count during 1990, which involved recording the numbers of dead hedgehogs seen on roads in July, August and September, with mileages and surrounding habitats being recorded also. Dr Pat Morris reported (pers. comm.) that records received nationally for 1990 totalled many thousands of miles driven. He has now to analyze the data to establish whether counting road casualties gives an index to the hedgehog population or to road traffic.

Kristiansson (1990) suggested that the population size of hedgehogs in his study appeared to be more influenced by environmental factors, such as food availability, winter nest sites and winter climate, than by density-dependent factors. Traffic kills were a predominant cause of mortality of non-juveniles.

CHIROPTERA (bats)

Mitchell-Jones (1990) reviewed information collected from local Bat Groups and others, following notifications to the Nature Conservancy Council. Distribution maps based on these reports showed ten species found in Avon and the surrounding district. A National Bat Sites Database is maintained by NCC, recording locations of sites and numbers involved. A National Bat Habitat Survey was started in 1990 which involved walking transects across 1km squares with bat detectors set on 45 kHz, recording any evidence of bats. (*Batchat*, NCC, No. 13, January 1990).

Mayle (1990) reviewed comprehensively the importance of woodlands for roosting, feeding, water and breeding for bats, and gave useful guidelines for the enhancement of forests for bats, including the use of bat boxes. In 1990 Avon Bat Group erected bat boxes at sites around Chew Valley and Blagdon Reservoirs, with financial assistance from Avon County Council. The boxes will be monitored regularly to check on their success.

A training course for those involved in the building industry on what to do if bats are encountered was held at Ashton Court in May by NCC and Vincent Wildlife Trust. Jim Jayne, the NCC's bat representative for Avon, was appointed as Trainer for Avon for batworkers (*Batchat*, NCC, No. 13, January 1990).

Bat records from the Avon Bat Group for Avon for 1990 have been compiled by Dr Gareth Jones, Department of Zoology, University of Bristol. Contributors from the Avon Bat Group were: Gareth Jones (GJ), David Clarke (DC), Jim Jayne (AFJ), Mark Brookes (MB), Patrick Cashman (PC), Tony Robinson (AR), David Trump (DPCT), and Robert Cropper (RC).

Greater horseshoe bat *Rhinolophus ferrumequinum.* Avon Bat Group reports:- "15 on 20 January, one on 7 April at ST5838. 153 in SE stone mines, January. Three in a sea cave ST4274 on 30 April; up to three, ST7069 (DC); one at a new site ST7779 on 12 October (DC). Up to two at ST4563 in October, 16 at ST 7966 in December (DC). New nursery site discovered - up to 60 babies born, and a maximum of 112 adults counted out prior to births. Up to 24 noted at spring 'fattening-up' site. Radio-tracking records from ST4974, 4672, 4673, 4773, 4472, 4572, 4372, 4273, 4371, 4471, 4971, 5170, 5171, 5071, 4665, 4666, 4464, 4564, 4663, 4463, 4563, 4462, 4562, 4863, 4859, 4359."

Lesser horseshoe bat *Rhinolophus hipposideros.* Avon Bat Group reports:- "Seven at ST3559, on 14 October was the most ever recorded at this site (RC). 16 at ST5838 on 7 April, 18 on 20 January. 82 in SE stone mines in January. Records from ST7765 (PC), and also seen at ST4563 (GJ)."

Pipistrelle *Pipistrellus pipistrellus.* Avon Bat Group reports:- "Males recorded at Horfield ST5976 20 March, Old Sodbury School ST7581 5 April, and Portishead (Holly Ridge) November. Females at Brislington ST6270 9 May, Portishead ST4576 25 May, Clevedon ST4071 25 May, Wrington ST4761 July, and Clifton ST5873 on 5 November. Juvenile female at Long Ashton ST5470 September. Old record from East Harptree ST5755. Bat detector records from ST 4665, ST4663, ST5060 and ST4563 (GJ); song flight in ST4472 during October; one seen at Bristol City football ground ST 5771 (AFJ)." Hughes and Jones of Bristol University, with others (Hughes *et al.* 1989), demonstrated in laboratory studies that pipistrelles suckled only their own young throughout the lactation period, although young attempted to solicit milk from any female. They predicted that a similar situation would prevail in the wild, although indiscriminate suckling may occur during conditions of high juvenile mortality, when many lactating females have lost babies, or in exceptionally large colonies where location of offspring may be difficult.

Leisler's Bat *Nyctalus leislerei.* Avon Bat Group reports:- "Juvenile on 13 July at Picton Street, Montpelier, Bristol ST5974." A distribution map for Leisler's bat (*Batchat*, NCC, No.14, June 1990) showed records from 1989 for Avon, and a table showed that these were records of juveniles.

Noctule *Nyctalus noctula.* Avon Bat Group reports:- "Bat detector records from ST4666 where several bats foraged around street lights in springtime, ST4673, and from ST4571 (GJ). Seen over Bath RFC ST7564 and St. George Park, Bristol ST6273 (MB). Bat detector record from ST5468 (DPCT). The Willsbridge roost tree was damaged in the winter gales; a box now stands on the stump of the old pine. About 20 at Blagdon Lake ST5060 on 1 May."

Serotine *Eptesicus serotinus.* Avon Bat Group reports:- "Old record from Eastwood Manor ST5655 from droppings, 4 September 1985. Bat detector record ST4471 in October. Mitchell-Jones (1990) reported that the Serotine appears to be more dependent on buildings than any other bat species, only once having been found from an underground site."

Daubenton's bat *Myotis daubentonii.* Avon Bat Group reports:- "Present at Abbot's Pool in good numbers, summer (GJ). A 1989 record from ST5456 on 31 December."

Natterer's bat. *Myotis natteri.* Avon Bat Group reports:- "Records from ST4259 for 11 March, and old record from same location, 1 January 1989."

Whiskered/Brandt's bat *Myotis mystacinus/brandtii.* Avon Bat Group reports:- "Female Whiskered from Compton Martin ST5457 22 August. Four Whiskered/ Brandt's from Brown's Folly 30 December (DC). Two Whiskered/Brandt's at Chew Stoke ST7765 on 21 February (AFJ). Whiskered/Brandt's identified from sonographic analysis, Prior's Wood, Portbury ST4974 on 2 May. Female Brandt's at ST5565 on 11 March (RC)."

Brown long-eared bat *Plecotus auritus.* Avon Bat Group reports:- "Abbot's Leigh ST5473 on 9 February. Oiled male from Bitton ST6869 on 4 June. One found long dead, ST4463 in June. Female at Brislington, dying, ST6270 on 14 September. Old Sodbury School ST7581 on 17 October. Hibernation record, Banwell ST5838 on 25 January (PC). Old record from ST5655 on 31 December 1989 (RC)."

LAGOMORPHA (rabbits and hares).

Brown hare *Lepus capensis.* MAFF carried out exhaustive tests into allegations that the herbicide Gramoxone may have caused mortality in hares, but no link was established. It was suggested that a viral disease similar to that found in rabbits might have been responsible for any mortality. Farmers were asked to report any suspicious deaths of brown hares, so that carcases could be checked for viral symptoms in addition to being screened for any pesticide residues (*Hansard*, 4 December 1990, WA 65).

Rabbit. *Oryctolagus cuniculus.* The Government reported that the rabbit population of the United Kingdom was estimated at 30 million, one third of the number before myxomatosis. Damage to agriculture and horticulture was estimated to cost £100 million to £150 million annually (*Hansard*, 25 July 1990, WA 254). Concern was expressed about the possible importation of Viral Haemorrhagic Disease (see below).

RODENTIA (rodents)

Common Rat *Rattus norvegicus.* Mr H. R. Nowell (Principal Environmental Health Officer, Bath City Council) reported that 509 complaints of rats had been received in 1990 compared with 446 in 1989, and considered that these represented a continuation of the trend of recent years. Mr R. H. Bevan (Pest Control Manager, Bristol City Council) reported a 13% reduction in numbers of complaints and requests for treatment against rats: 1193 in 1990 compared with 1348 in 1989.

Black Rat *Rattus rattus.* ADAS archive material unearthed in the year included a 3·2 inch square glass lantern slide of a map of England and Wales showing the distribution of *Rattus rattus* in 1945. This showed "extensive" infestations of Ship or Black Rat at 27 locations in England, including Bristol and Gloucester, and at five locations in Wales. Infestations were "known but not general" at 42 locations in England, including Cheltenham, and one in Wales. A further map in ADAS archives showed distributions of established populations in England and Wales in 1951 and 1956. Ship rats were shown to be established in both years at Bristol, Avonmouth, Sharpness and Gloucester, but not at Cheltenham. As reported last year, it is thought that *Rattus rattus* is now close to extinction in Britain.

House mouse *Mus domesticus.* Mr H. R. Nowell (Principal Environmental Health Officer, Bath City Council) reported that 346 complaints of house mice had been received in 1990, compared with 396 in 1989. Mr R. H. Bevan (Pest Control Manager, Bristol City Council) reported a 23% increase in numbers of complaints of house mouse problems, from 1289 in 1989 to 1587 in 1990.

Dormouse *Muscardinus avellanarius).* P. Bright, Conservation Officer of the Mammal Society, who is based at the Department of Zoology, University of Bristol, organised a national survey to attempt to establish how large a wood is needed to support a viable population of dormice. A new mammal study group, the Avon Dormouse Group, was established in Avon in 1990. The co-founders were David Clarke and Matthew Morton. They were working particularly on location of sites and on methods of protecting the habitat. Nestbox schemes were introduced in three areas and were very successful. Food remains were also a useful way of identifying dormouse locations.

Water vole *Arvicola terrestris.* Useful hints on methods of studying the distribution of water voles were given by Woodroffe *et al.*, (1990). They showed that at core sites latrine surveys are useful, but only during the breeding season, and that tracking provides the best evidence of the presence of water voles at peripheral sites.

Squirrels. Searches through "archives" at ADAS revealed the original maps used by MAFF in 1959 to record the presence or absence of red squirrels (*Sciurus vulgaris*) and grey squirrels (*S. carolinensis*) throughout the south-west of England. The results of the survey (Lloyd, 1962) showing distribution on a 10 km square basis, whilst the archive maps show the distribution on a parish basis. The maps will be deposited in biological records centres for the appropriate counties.

SMALL MAMMALS

Trapping continued for an eighth year in spring and autumn at the ADAS small mammal hedgerow sites (Trump, 1991). At the species-rich site at Falfield, 796 trap-nights in spring produced 12 small mammals: 1 woodmouse, 8 bank voles, and 3 common shrews. The autumn session, also of 796 trap-nights, resulted in a catch of 46 small mammals: 35 woodmice, 5 bank voles, 5 common shrews and 1 pygmy shrew. The catch of shrews was low compared with 1989 (16), and one suggestion was that the dry weather may have affected the population.

CETACEA (whales and dolphins).

Whilst dolphins are protected against deliberate capture by the Wildlife and Countryside Act 1981 and the Whaling Industry (Regulation) Act 1934, an initiative by the UK led to the adoption by the North Sea Conference Forum of a plan concerned with the conservation of all species of small cetacean (*Hansard*, 13 December 1990, column 473). Responding to concern expressed about catches of mammals in drift nets, the Government said that whilst incidental catches were known to occur, the numbers involved were not thought to be significant, and certainly no species were thought to be endangered from catches in drift or other sorts of nets. It was pointed out that drift nets are used around UK in localised small-scale fisheries only (*Hansard*, Lords). The Government also reported that proposals were being studied for projects to study marine mammal strandings, which would include small cetacean species, in coastal waters of England and Wales, including tissue sampling, post mortem examinations, analysis of contaminants and other tests as required.

The Whale and Dolphin Conservation Society, which reports its aims as being the conservation and protection of whales and dolphins, is based in Bath, Avon.

CARNIVORA (carnivores)

Badger *Meles meles*. Caroline Collett, Chairman of Avon Badger Group, sent their Report for 1990. Members had been active on problems of sett destruction and habitat loss due to land development, and with damage by badgers to gardens and farmland. A sett alarm was tried out at Pilning. 43 public events were attended by the Group. Records of setts in Avon were put onto a database and the setts were monitored regularly. Caroline reported that populations in Avon had been affected by the MAFF bovine tuberculosis policy. Also, the spring/summer drought affected cubs particularly, while the adults coped more successfully by feeding on snails, wasp nests and cereals. 75 road casualty deaths were recorded in Avon.

A Bill for the protection of badger setts was introduced by Mr Tony Banks and others, who emphasised that the badger was not an endangered species and that the aim was to protect the badger against cruelty (*Hansard*, 23 January 1990, pp. 747-748). This Bill fell at its third reading in July 1990. Another Bill, promoted by Mr Hughes and others, to make provision for the protection of badger setts had its first reading on 5 December. (*Hansard*, 5 December 1990). A briefing paper on the Bill to protect setts (League Against Cruel Sports, 1990) reported that a recent national survey by Bristol University Zoology Department put the badger population at 250,000 adults, producing 105,000 cubs a year. Also included was a reference to a large active sett in Avon having been found dug out and trenched in March 1990.

A National Badger Carcases Survey operated by MAFF was terminated in 1990. It was reported (*MAFF Phoenix*, November 1990, p. 14) that between 1972 and 1989 1,002 badger carcases from Avon submitted by the public were examined by MAFF veterinarians, of which 75 were positive for bovine tuberculosis. It was reported that MAFF will continue to accept carcases which are handed into the Veterinary Investigation Centre (at Langford), particularly any from areas of high TB infection in cattle, but in other areas the local authority should be contacted with regard to disposal of any road casualties.

The Minister of Agriculture was asked about evidence that badgers can transmit bovine tuberculosis to cattle. The reply (*Hansard*, 23 April 1990, WA 90) included the information that since the removal of all badgers from a study area in Avon (the Thornbury area) during 1981, there have been no instances of tuberculosis infection in cattle in the area. The Minister of Agriculture was asked if he intends to replace the existing badger control strategy with a policy of vaccination and live testing. The answer was that, if those measures took a form that would be effective in field conditions, the present strategy could be comprehensively revised (*Hansard*, 3 May 1990, WA 640). A diagnostic test for use in badgers was showing some promise; it was hoped that a field trial to study its effectiveness would start in September 1990 (*Hansard*, 19 April 1990 WA 979-980).

Useful advice on surveying for badgers was made available in the Mammal Society's *Surveying Badgers* (Harris *et al*., 1989).

Fox *Vulpes vulpes*. It was reported that there are no official estimates of fox populations in England (***Hansard***, 23 April 1990, WA 12). No government money is spent on fox population control, the occupiers of land being responsible for control. Trewella & Harris (1990) of Bristol University's Department of Zoology used data from a long-term study of foxes in Bristol to help clarify conflicting views on the effects of railways on urban fox numbers and dispersal movements. They claimed that the presence of railway lines does not affect the direction or distance that a fox may disperse. Whilst foxes use railway lines for natal earths, the majority of breeding sites are in gardens, and other habitat features rather than lines are more important in determining urban fox numbers. They concluded that in a rabies event, control operations should not concentrate solely on railway lines but would have to encompass a wide range of habitats, particularly back gardens.

Otter *Lutra lutra*. A consortium has been set up in Wessex to assist otters. The project is funded largely by NRA, NCC and the RSNC's Otters and Rivers Project, and will begin by carrying out surveys to clarify the distribution of otters. It will then look into how the growth of the population can be encouraged. (*AWT Newsletter*, 1990).

The Government suggested that the legal protection afforded to otters, and the reduction in the use of organochlorine insecticides, both seemed to have contributed to the apparent recovery in the distribution of the otter population, including in the south-west, as was shown by the two surveys carried out in 1977-1979 and 1984-1986. They reported that, whilst they were unaware of any studies which directly linked exposure to polychlorinated biphenyls to damage to otters' wombs, several studies suggested an indirect influence of PCBs on the reproductive performance of otters (*Hansard*, 17 May 1990, WA 550 - 511).

Penny Howell, formerly of the Vincent Wildlife Trust Otter Haven Project, set up an otter consultancy at Street with the aid of the enterprise allowance scheme.

PINNEPEDIA (seals)

The legal protection given to seals has been extended as described below. Advice on the difficulties faced in trying to rear seal pups was given by Mayer & Hutchison (1990). Without assistance orphaned pups starve because they have no blubber reserves to rely on while they learn to fish. Seal pups are relatively unable to digest lactose, seal milk being virtually free of lactose. The authors show that primary care of seal pups can be successful, even using dog kennels. They warn that seal bites can be serious, and can result in a condition known as "seal finger"!

The latest figures on populations of grey and common seals around the coasts of England and Wales, based on surveys carried out by the Sea Mammals Research Unit in 1990,are 7,000 grey seals, and 2,000 common seals (*Hansard*, Lords).

ARTIODACTYLA (deer).

A bill introduced to Parliament to prohibit the hunting and killing of deer with dogs was not successful. The National Trust was reported to have decided not to implement a ban on stag hunting on its properties and was to set up a two-year study of stag-hunting and its effects on the deer.

CHANGES IN LEGISLATION

Following expiration of orders under the Conservation of Seals Act 1970, and as a result of the viral epidemic which affected common seals in particular, further protection was afforded by the Conservation of Seals (England) Order 1990 (*Hansard*, 29 November 1990; 13 December 1990). This provided year-round close-season protection for three years along the North Sea and south coasts. A new development was that the Order applied to both common and grey seals.

A Bill to amend the Wildlife and Countryside Act 1981 sections 5 and 11 was read for the first time (*Hansard*, 5 December 1990).

WILDLIFE DISEASES

J. R. and R. E. Best, Veterinary Surgeons, of West Hill, Portishead, reported involvement in the treatment and rehabilitation of various wild mammal species.

The Government announced in April that the Institute of Terrestrial Ecology were under contract to review existing knowledge and assess future needs on wildlife disease generally, including marine mammals (*Hansard*, 25 April 1990, 258-259).

Information on the range of diseases found in wildlife was reported in a study from Cornwall (Euden, 1990), where 7·2% of badgers examined were infected with Salmonella, *S. agama* being the commonest and most widespread serotype (63% of total isolates); 25 other serotypes were isolated from badgers. Three serotypes of salmonellae were isolated from foxes. The diseases identified are of importance to farmers but the significance of their presence in badgers and foxes is not clear.

A moribund adult female hedgehog which died soon after it was received at a veterinary centre in Newcastle was considered to have died of hepatitis caused by a herpesvirus. This was believed to have been the first reported case of a herpesvirus in a hedgehog (Stack *et al.*, 1990).

The Government reported that, to prevent rabies-infected animals from entering the United Kingdom through the Channel Tunnel, measures were to include the use of physical barriers and grids, the continuous use of baited traps in the tunnel and terminal areas, and vigorous cleaning and inspection procedures (*Hansard*, Lords, 27 November 1990). To minimise casualties in a fox control operation, it was reported that baits would be used which would be more attractive to foxes than to other species, and that they would be buried in such a way as to make them more likely to be taken by foxes. It was reported that a control exercise would last for only one or two days (*Hansard*, 26 April 1990, WA 315).

Stephen Harris and Graham Smith of Bristol University's Department of Zoology have developed a model to show how an outbreak of rabies might spread among urban foxes (Harris & Smith, 1990). Field trials in Bristol confirmed that it is very difficult to get over 40% of foxes to take a bait, so oral vaccines would achieve little in the City. Killing foxes, although an unpleasant option, seemed the best way to deal with rabies in Britain. Maps show a computer prediction of how rabies would spread in the Bristol area if a family of foxes was infected in September.

VHD is the accepted name for viral haemorrhagic disease of rabbits, which was first reported from China in 1984 among rabbits imported from West Germany. This highly contagious disease has affected small family-run rabbit units more severely than large commercial units. It affects wild rabbits also but little is known about any effects on wild populations, although there is a report from Spain of VHD causing 60% mortality. There have been no reports of the disease in this country, but there is concern that it might be introduced illegally.

TECHNIQUES OF STUDYING MAMMALS

Harris *et al.* (1990) reviewed literature on home-range analysis using radio-tracking data. They drew attention to some of the problems encountered in their own studies of large mammals in Bristol and provided useful guidance for anyone intending to undertake a radio-tracking study.

EXOTIC MAMMALS

Baker (1990) reviewed the status of 15 species of exotic mammals naturalized in Britain, and the problems they cause, emphasising the need for vigilance and for any such exotics to be reported to MAFF. A species with a large number of individuals reported in the wild was the racoon, *Procyon lotor* with 24 individuals reported, the longest time free being about four years. A distribution map shows a record in the Bristol area. It was considered that the apparent release of racoons had been a response to new licensing conditions imposed.

CONSERVATION

Mr S. Minton, Forestry Commission Forester at Marlborough, reported no obvious changes in mammal populations in FC forests in the west. Increasing glades and widening rides to benefit butterflies and flora will surely benefit mammals also. Leigh Woods was reported as being managed for conservation objectives.

WILTSHIRE MAMMAL RECORDER

Mammalogists in Avon were saddened in 1990 to hear of the death of Mrs Marion Browne, Mammal Recorder for Wiltshire, and a member of the Bristol Naturalists' Society.

ACKNOWLEDGMENTS

The authors are grateful to all who provided information for this 1990 Avon Mammal Report, and hope that all contributions have been reported fairly. Others who responded to the questionnaire, but did not have information to contribute this year included Miss Pamela Bury (Avon FWAG Adviser), Mike Oxford (Avon County Ecologist), and the Department of the Environment.

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BRISTOL BOTANY IN 1990

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In a year which was reported as the warmest ever known on Earth, the weather in the Bristol area was no exception. Temperatures for the whole year were about 1°C higher than the fifty-year average, the period January to March being exceptionally mild, with temperatures averaging more than 3°C above normal, and with as few as five ground frosts recorded in that period. Rainfall was well below average, totalling only 791mm for the year (90·1% of normal). March to May was very dry (62mm), having as little as about one-third of the average rainfall. On the other hand, January, February and October were very wet, accounting for almost exactly half of the total rainfall for the year. A storm of extraordinary severity on 25 January resulted in heavy losses of trees in some places near Bristol. Over 500 trees were reported lost from Weston Big Wood, and many were also blown down in King's Wood, Axbridge, including old specimens of *Tilia cordata,* the wood's finest feature, PJMN. There was less severe loss in Leigh Woods where about one hundred trees were destroyed in the National Trust's part of the wood. On parts of the coast large amounts of floating debris were blown ashore and deposited, especially in the salt marsh and at the edge of the dunes at Berrow.

With the very mild start to the year the season was an early one, a few flowers of *Daphne laureola* being open in Cheddar Wood in the first week of January, and *Helleborus foetidus* was flowering towards the end of the month at Churchill and Goblin Combe. Spring was well under way by the latter part of February, when *Carex humilis* was in flower on Brean Down, *Lathraea squamaria* at Sidcot and Langford, and *Helleborus viridis* at its sites in Upper Langford, Winterhead Farm, Failand Hill and Ashton Court Park, RSC. The hot dry summer gave another good season for *Cyperus fuscus,* but some annuals were droughted and wilting was shown by certain perennials. The flowering season was prolonged well into the end of the year; at Berrow *Cakile maritima, Erodium cicutarium, Silene alba, Trifolium arvense* and *Euphorbia paralias* were all flowering in November, RSC. The profuse flowering and fruiting noted in all species of *Sorbus*, PJMN, was probably related to the long warm summer of 1989.

Two informative papers relevant to the plant ecology of the Bristol area were included in the *Proceedings of the Somerset Archaeological and Natural History Society* for 1989, Vol. 133. One, by R.M. Payne, is entitled 'The flora of walls in the Chew Valley' (pp. 231-242). In a detailed survey of 305 walls carried out in 1988 and 1989 no fewer than 291 taxa of flowering plants and ferns were recorded, although 25% of these occurred on only one wall. Most frequent, as on walls in Wiltshire, were Dandelion, Nettle and Ivy. However, *Poa annua, Chamaenerion angustifolium* and *Dryopteris filix-mas* were much scarcer than on walls in many other parts of England. Perhaps surprising are the total absence of *Desmazeria rigida,* the infrequency of *Parietaria judaica* and the more frequent occurrence of *Poa nemoralis* than of *P. compressa.*

The second paper ('Mud plants' in North Somerset in 1989, pp. 243-246), by Rosemary Fitzgerald and Liz McDonnell, describes the plants occurring in 1989 in the dry mud exposed after the summer drought at Cheddar Reservoir, Blagdon Lake and Chew Valley Lake. 'Gleaming beadlets' of the xanthophycean alga *Botrydium granulatum* were abundant at all three sites, 'beautiful rosettes' of the hepatic *Riccia cavernosa,* as well as miniature plants of *Chenopodium rubrum.*

Detailed studies of the vegetation of the 'Marsh Pea Plot' at Catcott in the Somerset Levels by Mrs M.P. Hill-Cottingham and A.G. Smith have quantified the considerable changes which have taken place in this part of the peat moors in recent decades. The relative effects on the species composition of clearing the strongly tufted grass *Molinia caerulea* and of burning are reported in a paper entitled 'The removal of *Molinia caerulea* from burnt and unburnt areas of Catcott Parish Plot' (*Proceedings of the Somerset Archaeological and Natural History Society* for 1988, Vol. 132, pp. 319-329). *Molinia,* now the dominant herbaceous plant in the plot, was shown to reduce species-richness and needs to be managed to maintain diversity. In a comparison of the vegetation of the plot in 1987 with that in 1964 ('Floristic changes after twenty-three years on a fen meadow at Catcott', *Ecology in Somerset*, Somerset Trust for Nature Conservation, 1990, Vol. 1, pp. 33-44), the same two authors show that the site is now drier, is being encroached by scrub and that the three major plant communities recognized in 1964 (Willis, A.J., these *Proceedings* for 1966, Vol. 31, pp. 297-304) are no longer distinct. The rare Marsh Pea, *Lathyrus palustris,* and *Cladium mariscus* survive, but a number of species have declined or disappeared, e.g. *Carex lasiocarpa, Dactylorhiza* spp. and *Equisetum fluviatile.*

Pride of place of the plant records for 1990 must go to *Orchis purpurea,* found flowering well in early May in Leigh Woods in the Avon Gorge, new to the Bristol area and to the whole of south-west England. Very probably the unusually warm weather of 1989, coupled with the favourable early season of 1990, promoted the growth of the Lady Orchid which may have been present in a vegetative state in the woods for a long time. Again this year plants not recorded since early this century, and feared lost from previously known sites, have been found to persist, notably *Filipendula vulgaris* on Brean Down and *Ornithogalum nutans* at Wickwar. *Trifolium suffocatum,* thought lost from North Somerset, persists at Berrow. The increasingly uncommon *Ranunculus arvensis* was reported from near Marshfield as well as *Scandix pecten-veneris.* Other records of uncommon plants include *Atriplex littoralis, Eleocharis uniglumis* and *Carex × pseudoaxillaris.* The moss *Gymnostomum recurvirostrum* from Walton-in-Gordano is new to v.c.6 and the liverwort *Riccia cavernosa* has been found once more at Berrow after a lapse of more than sixty years.

Names of contributors associated with several records, or with the determination of specimens, are abbreviated thus:

PJC	P. J. Chadwick	CK	Mrs C. Kitchen
RSC	R. S. Cropper	MARK	M. A. R. Kitchen
IFG	Miss I. F. Gravestock	DL	Miss D. Lawrence
IPG	I. P. Green	PM	P. Martin
PRG	P. R. Green	RDM	R. D. Meikle
ALG	A. L. Grenfell	RM	R. Milne
RH	R. Higgins	PJMN	P. J. M. Nethercott

The area covered by this report is essentially that defined by J.W. White for his *Flora of Bristol* (1912), with the addition of that part of the old county of

Gloucestershire lying between the eastern boundary of White's area and the Wiltshire border. The southern limit is taken as approximately the course of the River Brue along some of its length. The area comprises the northern part of the Watsonian vice-county of North Somerset (v.c.6) and the southern part of West Gloucestershire (v.c.34). In the following records these parts are designated S and G respectively.

Asplenium marinum L. Still thriving on cliffs at Redcliff Bay, Portishead, S, and at Clevedon, S, RSC.

Ophioglossum vulgatum L. In ridge and furrow pasture, near Oldbury, G, and in two sites near Hill, G, CK and MARK.

Ranunculus arvensis L. In potato field, with *Euphorbia exigua* L., *Kickxia spuria* (L.) Dumort., *Legousia hybrida* (L.) Delarbre, *Silene noctiflora* L. and *Stachys arvensis* (L.) L., near Marshfield, G, RH and DL.

R. parviflorus L. A small patch in limestone turf, Loxton Hill, S, and persisting in sparsely vegetated areas of Sand Point, S, RSC.

R. lingua L. Pond, near Warmley, G, RH and DL.

Thalictrum flavum L. Large patch in ditch crossing pasture, near Hill, G, CK and MARK.

Ceratophyllum submersum L. Abundant in rhyne, near Oldbury-on-Severn, G, CK and MARK.

Papaver lecoqii Lamotte Drove, Chilton Moor, S, and, with *P. dubium* L., along drove, Westhay Moor, S, RSC.

Corydalis claviculata (L.) DC. A small patch persisting in woodland on bank of the River Frome, Algars Manor, Iron Acton, G, CK, MARK and ALG. The character of the small Pennant Sandstone gorge has been much altered by river works.

Raphanus maritimus Sm. On newly made road verge, some distance inland from the main coastal population, Severn Beach, G, CK and MARK.

Cakile maritima Scop. A few plants, recently arrived after winter storms, in sand at the mouth of the River Brue, Burnham-on-Sea, S, RSC. Also two small patches of *Euphorbia paralias* L. and about twenty plants of *Salsola kali* L., RSC.

Cochlearia anglica L. One plant on right bank of the River Avon at Crew's Hole, G, PJMN. This site is higher up the river than the former St Anne's Ferry, noted by J.W. White, *Flora of Bristol,* 1912, p. 156.

Hypericum maculatum Crantz A patch on bank bearing scrub, Dodsmoor, G, CK and MARK.

Silene noctiflora L. One plant in cereal field adjoining Churchwood Quarry, Wickwar, G, CK and MARK.

Arenaria leptoclados (Reichenb.) Guss. Waste ground, Lamplighters Marsh, Shirehampton, G, IFG; also *Carlina vulgaris* L.

Scleranthus annuus L. Potato field, Hemington, S, IPG.

Montia fontana L. A good patch in wet woodland, South Moon Ridings, Wetmoor, and also Lance Coppice, near Inglestone Common, G, CK and MARK.

Chenopodium ficifolium Sm. Waste ground. Mill Pill Bridge, Sea Mills, Bristol, G, IFG. Several plants, with *C. album* L., on dumped soil, Berrow, S; also along drove, Chilton Moor, S, RSC.

C. murale L. Edithmead, Burnham-on-Sea, S, PRG. Also Steep Holm, S, CK and MARK.

Atriplex littoralis L. A few strong plants at top of salt marsh near the mouth of the River Brue, Burnham-on-Sea, S, RSC. Also four fine plants in sand on shore by newly-building dunes associated with the salt marsh, Berrow, S, RSC.

Halimione portulacoides (L.) Aellen On both banks of the River Brue near its mouth, Burnham-on-Sea, S, RSC.

Salicornia ramosissima Woods A small patch in salt marsh vegetation on shore, Berrow, S; also plentiful on bare mud, Uphill, S, RSC.

Malva neglecta Wallr. A pale pink form with small unstreaked flowers and greyish leaves, Shirehampton, G, IFG, det. ALG. On roadside verge, where also *Geranium rotundifolium* L., Tytherington, G, RSC. Also in garden, Berrow, S, RSC.

Genista tinctoria L. Abundant on railway cutting and bank of unimproved pasture, Wickwar, G, CK and MARK. Also in rough ground at edge of quarry, Shortwood, G, RSC.

Trifolium scabrum L. Plentiful, with *T. striatum* L., on southern slopes of Nyland Hill, near Draycott, S, RSC.

T. suffocatum L. A few flowering plants in short turf of dunes on Golf Course, Berrow, S, RSC. The Suffocated Clover is very rare in Somerset. Noted by J.W. White, *Flora of Bristol,* 1912, p. 236, as possibly extinct, this plant was reported last century from Weston-super-Mare on a site later used for building.

Lotus tenuis Waldst. & Kit. ex Willd. In 1987, with *Alopecurus bulbosus* Gouan, on sea wall, Northwick, G, RH and DL.

Ornithopus perpusillus L. Railway Hill, Mangotsfield, G, RSC.

Vicia orobus DC. More than thirty plants, several white-flowered, on grassy bank, Charterhouse, S, RSC.

Lathyrus montanus Bernh. Like *Daphne laureola* L., long persistent (see J.W. White, *Flora of Bristol,* 1912, pp. 255 and 522) in Cook's Folly Wood, Avon Gorge, Bristol, G, PJMN.

Filipendula vulgaris Moench Brean Down, S, RSC. Although recorded here last century, this plant was subsequently thought lost from this promontory (see R.G.B. Roe, *The Flora of Somerset,* 1981, p. 98). Also in small quantity on old earthwork embankment, Common Hill Wood, near Weston-in-Gordano, S, CK and MARK.

Rubus echinatus Lindl. Single bushes, Earthcott Green and Lance Coppice, near Inglestone Common, G, CK and MARK.

Potentilla tabernaemontani Aschers. Although declined in several sites in the Bristol area, it still grows in profusion on Wavering Down, S, PJMN. A further fine patch is persistent on rock outcrop, Rookham, S, RSC, where also *Cerastium pumilum* Curt. and *Myosotis ramosissima* Rochel.

Sanguisorba officinalis L. In unimproved pasture by Ladden Brook, Rangeworthy, G, MARK. In 1989, with *Hypericum maculatum* Crantz, *Potentilla* × *mixta* Holte ex Reichenb. (*P. reptans* L. × *P. anglica* Laichard.) and *Achillea ptarmica* L., on pasture on heavy clay, north of Iron Acton, G, RH.

Rosa rubiginosa L. One bush at edge of scrub, and also *R. micrantha* Borrer ex Sm. in several spots, Fry's Hill, Axbridge, S, RSC.

Crataegus laevigata (Poiret) DC. Single trees in hedge, Heath End, Tytherington (Moorleaze and The Slad) and Alveston, all G, CK and MARK.

C. × *media* Bechst. (*C. laevigata* (Poiret) DC. × *C. monogyna* Jacq.) In hedges, near Oldbury-on-Severn and near Itchington, G, CK and MARK.

Sorbus aria (L.) Crantz Single sapling whitebeams have established, presumably birdsown, in gorse thickets on the three hills Crook Peak, Compton Hill and Wavering Down, Mendip, S, PJMN. On Wavering Down and King's Wood (to the east) the whitebeams are on cliff and in woodland.

S. latifolia (Lam.) Pers. The finest specimen of this whitebeam, known since 1957, on Clifton Down, Bristol, G, PJMN, was very badly damaged in the storm of 25 January 1990 by the fall of a large *Pinus nigra* across it. This tree is the one referred to in the records by S.M. Walters and B.A. Miles in the paper by P.D. Sell on the *Sorbus latifolia* aggregate in the British Isles (see *Watsonia,* 1989, Vol. 17, Part 4, p. 396).

S. torminalis (L.) Crantz Two trees, near exit of West Wood, Rodney Stoke Woods, Mendip, S, PJMN and P.J. Mountford.

Daphne laureola L. Scattered in some of the remaining areas of semi-natural woodland, King's Wood, Yatton, S, PJMN.

Scandix pecten-veneris L. Plentiful in barley field, near Marshfield, G, RH and DL.

Silaum silaus (L.) Schinz & Thell. Kingston Seymour, S, and Banner Down, S, RSC.

Euphorbia platyphyllos L. Abundant, with *E. exigua* L., *Kickxia elatine* (L.) Dumort. and *K. spuria* (L.) Dumort., after earth-moving activities, gorse covert, near Patchway, G, RH and DL.

Rumex pulcher L. Plentiful on Nyland Hill, near Draycott, S, RSC. Also *Koeleria macrantha* (Ledeb.) Schultes.

Salix × *rubra* Huds. (*S. purpurea* L. × *S. viminalis* L.) East Huntspill, S, PRG, det. RDM.

S. × *sericans* Tausch ex A. Kerner (*S. caprea* L. × *S. viminalis* L.) In 1989, Shepton Mallet, S, PRG, det. RDM. Berrow, S, PRG and IPG, det. RDM.

Calluna vulgaris (L.) Hull Good colonies, with *Erica cinerea* L., Troopers Hill, St George, Bristol, G, PJMN. Now that much of the St George area has been rebuilt or expanded and Kingswood much expanded to the east, Troopers Hill becomes a desirable botanical site for conservation as acidic grassland. Also on this hill are scattered *Solidago virgaurea* L., small colonies of *Danthonia decumbens* (L.) DC. and frequent *Deschampsia flexuosa* (L.) Trin., PJMN.

Pyrola minor L. In wood clearing, Swangrove, near Badminton, G, DL.

Primula veris L. × *P. vulgaris* Huds. A fine clump, near both parents, on edge of fen meadow, Winscombe, S, RSC.

Samolus valerandi L. Bank of rhyne, Olveston, G, CK and MARK.

Blackstonia perfoliata (L.) Huds. Four large plants at edge of recently cleared ditch on dunes, Berrow, S, RSC, where not recorded in recent years.

Myosotis secunda A. Murr. Lawrence Weston Moor, G, RH and DL.

Verbascum virgatum Stokes Near Parkway Station, G, DL.

Linaria repens (L.) Mill. By railway, Highbridge, S, IPG.

Veronica spicata L. ssp. *hybrida* (L.) E.F. Warb. With *Carex humilis* Leyss., on a steep grassy area above quarry, Leigh Woods, Avon Gorge, Bristol, S, Libby Houston. These plants result from fragments, rescued during the latter phase of rock-blasting activities on the Clifton side of the Avon Gorge. They were transplanted in May 1981 by the then Leigh Woods Warden, Bob Russell, to what was considered a suitable site, not easily accessible and distant from known colonies of these plants. *Trinia glauca* (L.) Dumort. was also transplanted, but disappeared in the year of planting. *Carex humilis* is surviving well and has increased somewhat, and *Veronica spicata* has become very well established and spread vegetatively over a considerable area. The grassland patch is fairly herb-rich, including *Arabis stricta* Huds., with frequent *Ajuga reptans* L., *Cirsium acaule* Scop., *Hieracium pilosella* L., *Origanum vulgare* L. and *Solidago virgaurea* L., Libby Houston.

V. agrestis L. Abundant in cereal field, Wickwar, G, CK and MARK. One plant in garden, Burnham-on-Sea, S, RSC.

Stachys arvensis (L.) L. Frequent in cereal stubble, Latteridge, G, and at disturbed entrance to grass ley, Frampton Cotterell, G, CK and MARK. In 1987, on disturbed roadside, Patchway, G, RH and DL.

Galeopsis bifida Boenn. Small patch in hedge, Heath End, Cromhall Common, G, CK and MARK.

Sherardia arvensis L. In turf and at base of wall, Shirehampton, G, IFG.

Galium album Mill. Roadside, Walton-in-Gordano, S, CK and MARK.

Valerianella carinata Lois. Garden weed, Horfield, Bristol, G, RH and DL.

Senecio erucifolius L. Waste ground, Mill Pill, Sea Mills, Bristol, G, IFG.

Aster linosyris (L.) Bernh. Exceptionally fine (over 600 flowering stems) at Brean Down, S; also persistent at Uphill, S, RSC. Presumably favoured by the hot dry season.

Artemisia maritima L. Many fine patches, and also plentiful *Limonium vulgare* Miller, along left bank of the River Brue, Highbridge, S, RSC.

Cirsium × *celakovskianum* Knaf (*C. arvense* (L.) Scop. × *C. palustre* (L.) Scop.) Compton Bishop, S, H. Squire, conf. W.A. Sledge.

Onopordum acanthium L. Flourishing (65 spikes) on rough grass bank, Marshfield, G, PJC. Nine plants on roadside verge (cut before flowering), Shipham, S, RSC.

Centaurea cyanus L. With *Ranunculus arvensis* L., on disturbed soil in wheat field, Westerleigh, G, RH and DL. Also arable field resown to grass, Oldford, S, IPG.

Serratula tinctoria L. In small quantity, by track at edge of wood, South Moon Ridings, near Wickwar, G, CK and MARK.

Baldellia ranunculoides (L.) Parl. In 1989, pond, near Yate Rocks, G, RH.

Stratiotes aloides L. In rhyne, Huntspill, S, IPG.

Groenlandia densa (L.) Fourr. In rhyne, Binham Moor, S, RSC.

Zannichellia palustris L. Persistent, since 1976, in shallow pools in disused quarry, Shortwood, G, RSC.

Epipactis helleborine (L.) Crantz At margin of wood, Sandford Hill, S, RSC.

Spiranthes spiralis (L.) Chevall. Two plants, grassland, Clifton Down, Clifton, Bristol, G, PJMN. J.W. White, *Flora of Bristol,* 1912, p. 566, refers to Lady's Tresses as 'Very thinly scattered over Clifton and Durdham Downs'.

Platanthera chlorantha Custer (Reichenb.) One in rough grass, Ashton Court, Bristol, S, PJC.

Ophrys apifera Huds. Only thirteen flowering spikes on road embankment, Aust, G, PJC, and none seen at its two other sites by the M4 underpass.

Orchis purpurea Huds. A single, but vigorous, flowering plant, Leigh Woods, Bristol, S, K. B. Taylor, conf. Dr M. H. Martin and AJW. The Lady Orchid was on a sloping site, somewhat shaded by *Fraxinus excelsior* L. and *Corylus avellana* L. The moderately open ground flora was dominated by *Mercurialis perennis* L. but there was an appreciable cover of mosses, the site in no way appearing disturbed.

This totally unexpected find of the Lady Orchid is the first for south-west England and the only one in Britain on Carboniferous limestone. The associated flora is, however, entirely typical of *O. purpurea.* The orchid is now of very restricted occurrence in Britain outside Kent; the nearest records to the Leigh Woods plant are of a single specimen once present in Herefordshire and of a small colony in Oxfordshire. This addition to the Bristol flora may be considered the most notable since the publication of J.W. White's *Flora of Bristol,* 1912. Although he listed (p.36) a number of species which might be native of the district, and 'should be looked for', *O. purpurea* is not included. A full account of this orchid is given by A. J. Willis, M. H. Martin and K. B. Taylor, entitled '*Orchis purpurea* Hudson in the Avon Gorge, Bristol' in *Watsonia*, 1991, Vol. 18, Part 4, pp. 387-390.

O. morio L. A single plant, near Hill, G, CK and MARK. One plant, Loxton Hill, S, RSC.

Dactylorhiza fuchsii (Druce) Soó Very abundant in grassy clearing, Harridge Wood, near Nettlebridge, S, RSC.

D. maculata (L.) Soó ssp. *ericetorum* (Linton) P. F. Hunt & Summerhayes Charterhouse, S, RSC.

Anacamptis pyramidalis (L.) L. C. M. Richard One on grass verge, Cribbs Causeway, Bristol, G, PJC. A few spikes on limestone slope, Fortnight, S, RSC.

Lemna gibba L. In rhyne, Almondsbury, G, CK and MARK. This Duckweed appears to be now uncommon in North Avon, unlike the situation further south.

Eleocharis uniglumis (Link) Schult. For the last five years, with *Myosotis secunda* A. Murr., *Thalictrum flavum* L., *Triglochin palustris* L., *Isolepis setacea* (L.) R.

Br., *Carex nigra* (L.) Reichard, *C. disticha* Huds., *C. ovalis* Good., Lawrence Weston Moor, G, RH and DL.

Cyperus fuscus L. Flourishing well in the hot summer, Walton Moor, Gordano, S, RSC.

Carex strigosa Huds. In small quantity, by stream, Lance Coppice, near Inglestone Common, G, CK and MARK. Several clumps by path, Leigh Woods, Bristol, S, RSC.

C. pallescens L. In grassy woodland clearing, Harridge Wood, near Nettlebridge, S, RSC; also *C. demissa* Hornem.

C. humilis Leyss. A clump about 1 m in diameter, with seven small adjoining colonies, Compton Hill, Mendip, S, PJMN. This record reinforces the chain of this sedge, Brean Down, Crook Peak to Cross Plain, always on slopes of southern or south-western aspect.

C. × *pseudoaxillaris* K. Richter (*C. otrubae* Podp. × *C. remota* L.) With *C. pendula* Huds., *C. remota* L. and *C. strigosa* Huds., at margin of narrow woodland strip, west of Wetmoor, near Wickwar, G, CK and MARK, conf. A.C. Jermy.

C. disticha Huds. In pasture, Maniards Green, near Hill, G, CK and MARK.

C. spicata Huds. Waste ground, Shirehampton, G, IFG.

C. ovalis Good. Winscombe, S, RSC.

Glyceria plicata Fr. With *G. fluitans* (L.) R. Br. and hybridizing freely, Winscombe, S, RSC. Also at Portbury, S, RSC.

Puccinellia distans (Jacq.) Parl. Kingston Seymour, S, RSC.

Poa angustifolia L. On steep bank, Algars Manor, Iron Acton, CK, MARK and ALG.

Brachypodium pinnatum (L.) Beauv. Draycott, S, RSC.

Calamagrostis epijegos (L.) Roth Good patch by roadside, Earthcott Green, G, and by road hedge bank, Tytherington, G, CK and MARK. Large patch in old quarry, Shortwood, G, RSC. By old railway line, Winscombe, S, and three patches in scrub, Callow Hill, S, RSC.

ALIENS

Erucastrum gallicum (Willd.) O.E. Schulz Brent Knoll, S, PRG.

Barbarea verna (Mill.) Aschers. Stoke St Michael (Stoke Lane), S, PRG and IPG.

Rorippa austriaca (Crantz) Besser Fairly abundant on bank and along stream, adjoining mounds of dumped earth, Lawrence Weston, G, RM.

Erysimum cheiranthoides L. On disturbed ground, Stover, G, CK and MARK. With *Urtica urens* L., by track, Ox Bridge, near Westerleigh, G, CK, MARK, S.H. Bishop and G. Bishop. Flowering well on disturbed peat of new Nature Reserve, Westhay Moor, S, RSC.

Sisymbrium orientale L. Abundant on rough ground under motorway, Shirehampton, G, IFG. Sand Bay and Berrow, S, RSC.

Silene armeria L. Well established on rocky hummock on mound of dumped earth and masonry, Lawrence Weston, G, RM.

Geranium phaeum L. Several plants in shady spot near stream, Long Wood, Charterhouse, S, RSC. This site appears to be where Miss I.M. Roper recorded the plant (see J.W. White, *Flora of Bristol*, 1912, p. 211).

Melilotus alba Medic. Several plants on site of old railway station, Winscombe, S, RSC.

Lathyrus tuberosus L. With *Vicia villosa* Roth, on open hilly ground at edge of scrub, Crew's Hole, Bristol, G, and a few plants in scrub at roadside towards Conham, Bristol, G, RM.

Sanguisorba minor Scop. ssp. *muricata* Briq. Several plants, with *Chaenorhinum minus* (L.) Lange, in grass on railway embankment, Cranmore, S, RSC.

Pyrus pyraster Burgsd. In field hedge, Frampton Cotterell, and in green lane hedges at Latteridge and Hill, all G, CK and MARK.

Sedum dasyphyllum L. On walls in three sites, Frampton Cotterell, G, CK and MARK.

Myriophyllum aquaticum (Velloso) Verdcourt In rhyne, MARK, S, IPG.

Alnus cordata Desf. One bush in overgrown quarry, Penpole Point, Shirehampton, G, IFG.

Salix elaeagnos Scop. Croscombe, S, Karen Turvey, det. RDM.

Cyclamen hederifolium Ait. Overgrown lane, Stoke Bishop, Bristol, G, IFG.

Lysimachia punctata L. Small roadside patches, Earthcott Green and Latteridge, G, CK and MARK.

Symphytum asperum Lepech. A fairly large patch, with *S.* × *uplandicum* Nyman, on open grassy ground, Henbury, Bristol, G, RM.

S. caucasicum Bieb. Downhead, S, PRG.

Pentaglottis sempervirens (L.) Tausch A small but established colony, Bridge Valley Road, Clifton Down, Bristol, G, PJMN.

Solanum rostratum Dunal. With plentiful *Datura stramonium* L. and one plant of *Cotula coronopifolia* L., Sewage Works, Avonmouth, G, RH.

Verbascum blattaria L. On railway cuttings, Montpelier and Ashley Hill, Bristol, G; with *Rapistrum rugosum* (L.) All., Lamplighters, Shirehampton, G, RH and DL.

Melissa officinalis L. At base of wall, Alveston, G, CK and MARK. Edge of Downs, Henleaze, Bristol, G, IFG, where also *Meconopsis cambrica* (L.) Vig.

Prunella laciniata (L.) L. Persistent at Tytherington, G, RSC, but greatly outnumbered by its hybrid with *P. vulgaris* L.

Inula helenium L. A single spike on margin of narrow strip of woodland, Wetmoor, near Wickwar, G, CK and MARK.

Erigeron karvinskianus DC. One well-established plant below Black Rocks, Avon Gorge, Bristol, G, RM. Also a few plants on wall, Brent Knoll, S, RSC.

Silybum marianum (L.) Gaertn. One plant in long grass, Brandon Hill, Bristol, G, RM. Plentiful on disturbed ground of rabbit warren, Glastonbury Tor, S, where recorded last century and seen by PJMN in 1977 (many plants on disturbed ground on flank of hill). Also about a dozen plants along drove, Chilton Moor, S, RSC.

Ornithogalum nutans L. Flowering in hedgebank on roadside, Wickwar, G, CK and MARK; also M. Trotman and (later) RSC. This site is reported by J.W. White, *Flora of Bristol,* 1912, p. 587.

Cyperus eragrostis Lam. In 1988, but later lost, one plant in crack in concrete, by Locks downstream of Plimsoll Bridge, Bristol, G, RM.

Bromus diandrus Roth West Huntspill, S, IPG.

Phalaris canariensis L. One plant at base of wall, Shirehampton, Bristol, G, IFG.

Cynodon dactylon (L.) Pers. Naturalized along about 200 m of little-used railway line, Lawrence Hill, G, RH and DL.

BRYOPHYTES

Riccia cavernosa Hoffm. emend. Raddi On damp sandy soil at edge of pool, dunes, Berrow, S, PM. This liverwort was recorded (as *R. crystallina* var. *angustior)* by W. Watson from 'margin of dune pool, Berrow, 1926' (see J. Appleyard, 'A bryophyte flora of north Somerset', *Transactions of the British Bryological Society*, 1971, Vol. 6, p.11) but was regarded by Mrs Appleyard as extinct at this site ('habitat now gone').

Gymnostomum recurvirostrum Hedw. A depauperate form on damp rock face in 2ld quarry, Walton-in-Gordano, S, PM. This moss is new to v.c. 6.

Tortula subulata Hedw. var. *graeffii* Warnst. On tree trunk, at edge of wood, opposite quarry, Harridge Wood, near Nettlebridge, S, PM. This moss, normally found on rock or soil, is in an unusual habitat here; however, the quarry may have led to an accumulation of dust on the tree. This is the third record for v.c. 6.

ACKNOWLEDGEMENTS

I thank everyone who has supplied records and helped with these, especially Mr P. J. M. Nethercott and Captain R. G. B. Roe. I am indebted to Long Ashton Research Station for meteorological records.

THE COAST OF AVON

EDITED BY P. R. CROWTHER

ASSISTED BY A COMMITTEE

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CONTENTS

Introduction and Acknowledgements 2

Geology of the Avon coast, by A. B. Hawkins 3

The post-glacial geology and geoarchaeology of the Avon wetlands, by J. R. L. Allen 28

A history of *Spartina* on the Avon coast, by M. H. Martin 47

The development and vegetational history of Berrow salt marsh, by A. J. Willis 57

The mudflat ecosystem and epipelic diatoms, by D. M. Paterson & G. J. C. Underwood 74

Animals of Severn Estuary salt marshes, by C. Little 83

Birds of the Avon shore, by H. E. Rose 95

Heavy metal pollution in the Severn Estuary, by M. H. Martin & C. L. Beckett 105

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INTRODUCTION AND ACKNOWLEDGEMENTS

The Coast of Avon is the third in an occasional series of thematic volumes published by the Bristol Naturalists' Society, as 'Special Issues' of the annual *Proceedings*. Since its establishment in 1862, the Society has considered its home territory to extend far beyond Bristol *sensu stricto*, from the Mendips to the Cotswolds. Yet our first two Special Issues were restricted geographically to the city and its immediate vicinity - *The Avon Gorge* (published 1988) and *Bristol's Urban Ecology* (published 1991). The present compilation of papers by invited authors redresses the balance by focusing on the entire coastal margin of the Society's territory (thereby, of course, exceeding the geographical confines of the modern county of Avon, despite the book's title!).

Although it is impossible to do full justice to the geology and natural history of such a diverse region in the space available, each of the contributors to *The Coast of Avon* is a recognised authority in their field and I think they have collectively produced something for everyone - from the structure of the landscape, reflecting several hundred million years of geological evolution, to the modern legacy of our industrial society, heavy metal pollution in the Severn Estuary.

The Coast of Avon theme was devised by the Society's Publications Committee, and its members have been a continuing source of advice and expertise during the production period. Mr S. M. Taylor deserves special thanks: the quality 'look' of the pages is a tribute to his skills in desk top publishing, and his dedication to the project has helped to make publication an economic proposition for the Society. We have also benefited from generous sponsorship by the National Rivers Authority (Wessex Region), Wessex Water, Woodspring District Council, Avon County Council, and the trustees of the Hector Hockey Fund, all of whom awarded grants to help defray printing costs. The splendid cover picture, an aerial view of Sand Point (Middle Hope, looking east), was kindly provided by West Air Photography of Weston-super-Mare.

The Society is very grateful to all who contributed to the origination and production of this, our third Special Issue. I hope that readers will find it a stimulating introduction to *The Coast of Avon*.

Dr Peter R. Crowther, Hon. Editor. 7 March 1992

County of Avon

Wessex Water

WOODSPRING

NRA

National Rivers Authority
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GEOLOGY OF THE AVON COAST

by A. B. HAWKINS

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ABSTRACT

The orientation of the Avon coast has been strongly influenced by the Variscan structures and the valley system developed in the subsequent Permo-Triassic period. Some geological features of the coastal cliff sections are briefly described and attention is drawn to a number of the Pleistocene deposits of the coastal zone. The rise in sea level since the Late Devensian Glaciation is discussed in some detail, showing its influence on the characteristics of the alluvial sediments. The surface nature of these sediments, their higher level outside the sea walls, the tidal pills which cross them and the soft sediment cliffs eroded into them are considered.

INTRODUCTION

The Avon coast has a north-east/south-west trend which is broken only at the mouths of the River Avon and River Yeo. The Ordnance Survey maps indicate that rocks or cliffs are exposed along only one-third of the coast. Within the remainder alluvium forms the edge of the Severn Estuary but rock ledges can be seen at mean and low water level in places such as Severn Beach, Aust and Shepperdine. Off Severn Beach, where the Estuary is 3·5 km wide, it is possible at low tide to walk out more than 2 km from the high water mark; it is therefore not surprising that the English Stones area has been chosen as the site of the second Severn road crossing.

SOLID GEOLOGY

The shape of the Severn Estuary is dominated by the structural trends created during the Variscan Orogeny of Permo-Carboniferous age. This was responsible for the north-south alignment of the Bristol Coalfield/Forest of Dean area in the north and the four east-west trending periclines which together form the Mendip Hills in the south (Figure 1). At the junction of these major orogenic alignments are the north-east/south-west trending Vale of Gordano and the Westbury-on-Trym structures. It is clear, therefore, that the shape of the Severn Estuary and Bristol Channel has been significantly influenced both by the structural trends imposed during the Variscan and by the resistant nature of the Carboniferous Limestone.

The Variscan Orogeny folded *c.*1,000 m of Carboniferous Limestone and more than 2,000 m of Coal Measure strata to form mountains which would probably have reached 2,000 m in height, despite the natural erosion taking place as the mountains developed in the late Carboniferous, Permian and early Triassic periods. Contemporaneous with the denudation of these mountains, in the area of the present Somerset Levels south of the Mendip Hills over 1,000 m of Triassic sediments and evaporites accreted in a downwarp or graben structure (Green &

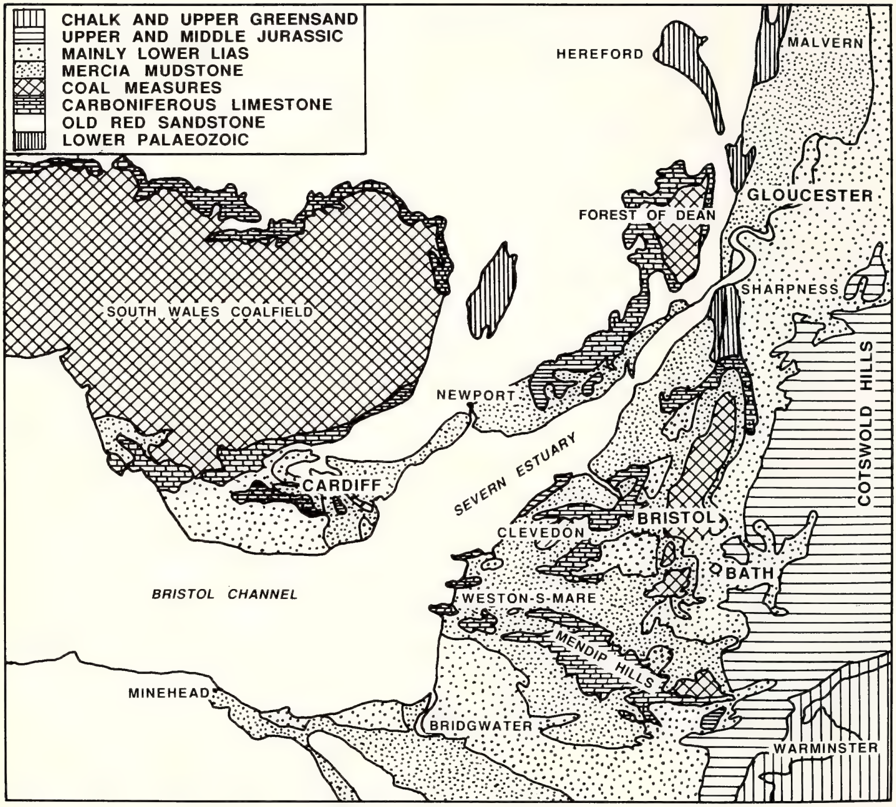

CHALK AND UPPER GREENSAND
UPPER AND MIDDLE JURASSIC
MAINLY LOWER LIAS
MERCIA MUDSTONE
COAL MEASURES
CARBONIFEROUS LIMESTONE
OLD RED SANDSTONE
LOWER PALAEOZOIC
HEREFORD
MALVERN
GLOUCESTER
FOREST OF DEAN
SHARPNESS
SOUTH WALES COALFIELD
COTSWOLD HILLS
NEWPORT
SEVERN ESTUARY
CARDIFF
BRISTOL
CLEVEDON
BATH
BRISTOL CHANNEL
WESTON-S-MARE
MENDIP HILLS
MINEHEAD
BRIDGWATER
WARMINSTER

FIGURE 1. General geology of the Severn Estuary region.

Welch, 1965). At the same time, significant valleys were created in the area, particularly along the line of the Severn axis as defined by Kellaway & Welch (1948). This post-Variscan valley system subsequently became infilled by a series of slope breccias, rock fans and playa deposits in the semi-desert environment in which the Dolomitic Conglomerate and Mercia Mudstone (Keuper Marl) accumulated. South of Sharpness the Mercia Mudstone forms the main bedrock strata below the alluvial cover adjacent to the Severn Estuary.

WESTON-SUPER-MARE

In the Weston-super-Mare area the three Carboniferous Limestone promontories of Middle Hope, Worlebury and Brean Down form pronounced topographic features which follow the east-west trend of the Mendip Hills (see Figure 2 for an interpretation of the main structural features). Here the sedimentology differs from that inland and in the Avon Gorge due to the presence of the Birnbeck Limestone and the more extensive dolomitization of the strata. The Birnbeck Limestone consists of two main facies: a grey, thickly bedded, finely cross-bedded, oolitic

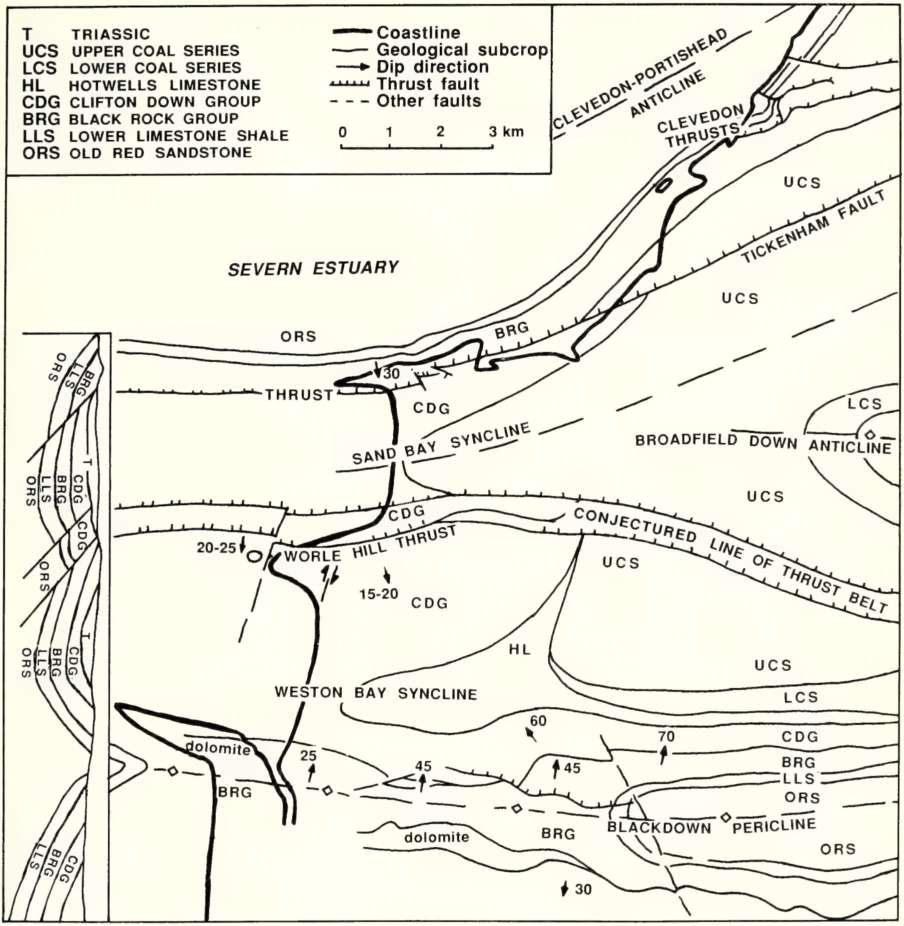
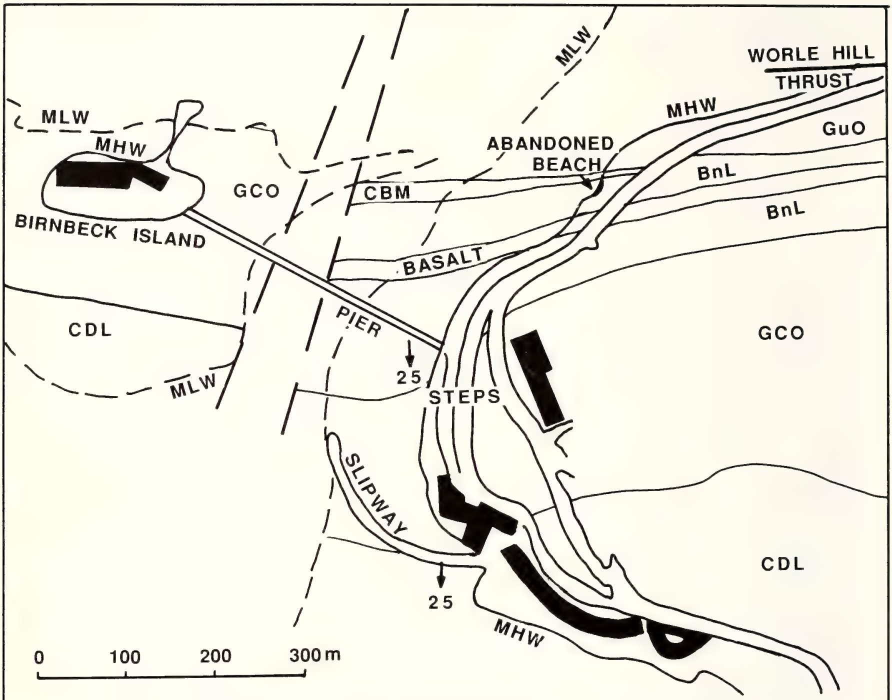

T TRIASSIC
UCS UPPER COAL SERIES
LCS LOWER COAL SERIES
HL HOTWELLS LIMESTONE
CDG CLIFTON DOWN GROUP
BRG BLACK ROCK GROUP
LLS LOWER LIMESTONE SHALE
ORS OLD RED SANDSTONE
Coastline
Geological subcrop
Dip direction
Thrust fault
Other faults
0 1 2 3 km
CLEVEDON-PORTISHEAD ANTICLINE
CLEVEDON THRUSTS
SEVERN ESTUARY
TICKENHAM FAULT
ORS
BRG
THRUST
30
CDG
SAND BAY SYNCLINE
LCS
BROADFIELD DOWN ANTICLINE
UCS
CDG
CONJECTURED LINE OF THRUST BELT
20-25
WORLE HILL THRUST
15-20
CDG
UCS
HL
WESTON BAY SYNCLINE
LCS
60
70
CDG
dolomite
25
45
45
BRG
LLS
ORS
BRG
dolomite
BRG
BLACKDOWN PERICLINE
ORS
30
ORS
LLS
BRG
T
CDG

FIGURE 2. Geological structure of the Carboniferous and older rocks in the Weston-super-Mare /Clevedon region. Modified from Whittaker & Green (1983).

limestone with few fossils, above which the limestones are generally well-bedded, fossiliferous and often bioturbated. The dolomitic siltstones which occur particularly within the upper facies of this member have frequently been preferentially eroded.

Worlebury Hill

Spring Cove, at the western end of Worlebury Hill, has some interesting features. Figure 3 shows the position of the outcrops of the strata between the Gully Oolite and the Clifton Down Limestone and gives a brief summary of the lithologies. Undoubtedly the basaltic pillow lavas within the Birnbeck Limestone are of greatest interest to most geologists (Plate 1A). In Spring Cove these possess an



CDL	**CLIFTON DOWN LIMESTONE:** Grey, thickly bedded and pinkish grey, thinly bedded, oolitic, bioclastic and dolomitic limestones.
GCO	**GOBLIN COOMBE OOLITE:** Grey, thickly bedded, oolitic and bioclastic limestones.
BnL	**BIRNBECK LIMESTONE:** Grey, thickly becoming thinly bedded and cross bedded, in part dolomitized, bioclastic limestones. Contains basaltic pillow lava, pyroclasts and bands of ash within the limestones and the Caswell Bay Mudstone (CBM) at base.
GuO	**GULLY OOLITE:** Pale grey, thickly bedded, oolitic limestones frequently with the top karstified as a consequence of Mid-Avonian Break.

FIGURE 3. Geology of the Spring Cove area, Weston-super-Mare, including a general description of the lithologies present. Modified from Whittaker & Green (1983).

irregular base, having accumulated over an eroded limestone surface, and the pillow structures (frequently up to 1 m across) have distinct, cracked, crusty rims (Speedyman, 1977). In addition to the thick lava band there are several metres of agglomeratic tuff containing both lava and limestone blocks. Both Speedyman (1977) and Whittaker & Green (1983) suggested that the agglomerate probably resulted either from secondary deposition of a submarine slide or by marine re-working. The raised beach seen north of the igneous rocks is less impressive than that at Swallow Cliff on Middle Hope (Briggs *et al.*, in press) but rests on a truncated marine platform about 5 m above the maximum height of the present storm beach. Not all the pebbles are rounded and shells are rare compared with the Swallow Cliff beach deposits. Furthermore, there are no intervening deposits between the marine cut platform and the fossil beach as seen at Middle Hope. Plate 1B, taken immediately to the north of the raised beach, shows a good example of the karstic features which developed at the top of the Gully Oolite during the Mid-Avonian Break, prior to deposition of the Caswell Bay Mudstone. Immediately north of this weathered surface, the broken nature of the rocks indicates the line of the Worle Hill Thrust, above which the Gully Oolite is extensively dolomitized.

Middle Hope

Although excellent exposures are visible at Worlebury, the section in the Black Rock Group at Middle Hope is better known to most geologists. In the Swallow Cliff area solitary and colonial corals can be seen in the crinoidal Black Rock Limestone, while the numerous chert globules, being more brittle than the host limestones, have been more highly fractured. It is the volcanic material, however, which attracts most attention in this section (Plate 2A). It is important to note that these volcanics are older than those at Spring Cove as they occur in the Black Rock Group rather than the Birnbeck Limestone overlying the Gully Oolite. Although the pillow lavas are less impressive than those at Worlebury, a thick ash sequence with numerous lapillae and extensive calcite veining is prominent (Speedyman, 1977). No lava is present in North Bay but here the ash horizons are very agglomeratic with clasts up to 200 mm in diameter. A visit to this bay also allows inspection of the 'pipe rock' (Plate 2B) which demonstrates the way molluscs burrowed vertically into the sediments (a feature highlighted here by the colour-laminated nature of the tuffaceous sediments).

CLEVEDON TO PORTISHEAD

There are many features of interest to the naturalist in the area between Clevedon and Portishead. At Clevedon the Black Rock Limestone forms the main lithology along the promenade section and it was here that Butler (1972) described the characteristics of the near-shore facies which occur within the faulted exposure of the Lower Limestone Shales. In the Walton Park area of Clevedon, the Dolomitic Conglomerate forms the cliff section. Here the disturbed, very large, gently seaward-dipping blocks are frequently separated by deep chasms between the rock masses. At Lady Bay the Dolomitic Conglomerate has been down-faulted to rest in juxtaposition with the Old Red Sandstone, while immediately north of the Bay the Conglomerate exhibits significant lateral variation as a consequence of the sediments having accumulated as rock fans prograding at right angles to the present coast (North, 1988).

In the Redcliff Bay area the classic unconformity between the Dolomitic Conglomerate and the Old Red Sandstone can be seen (Plate 3A). Elsewhere along the Portishead-Clevedon ridge the morphology eroded during the Permo-Triassic (250 million years ago) is mantled by the slope breccias of Dolomitic Conglomerate which here contains sub-angular clasts of up to 0·5 m in length, indicating a position close to the source area. Immediately south of the Portishead promenade excellent examples of cross-bedding and pebble-infilled channels can be seen within the interbedded sandstone/mudstone sequences of the Old Red Sandstone. Again the Dolomitic Conglomerate has been down-faulted into juxtaposition with

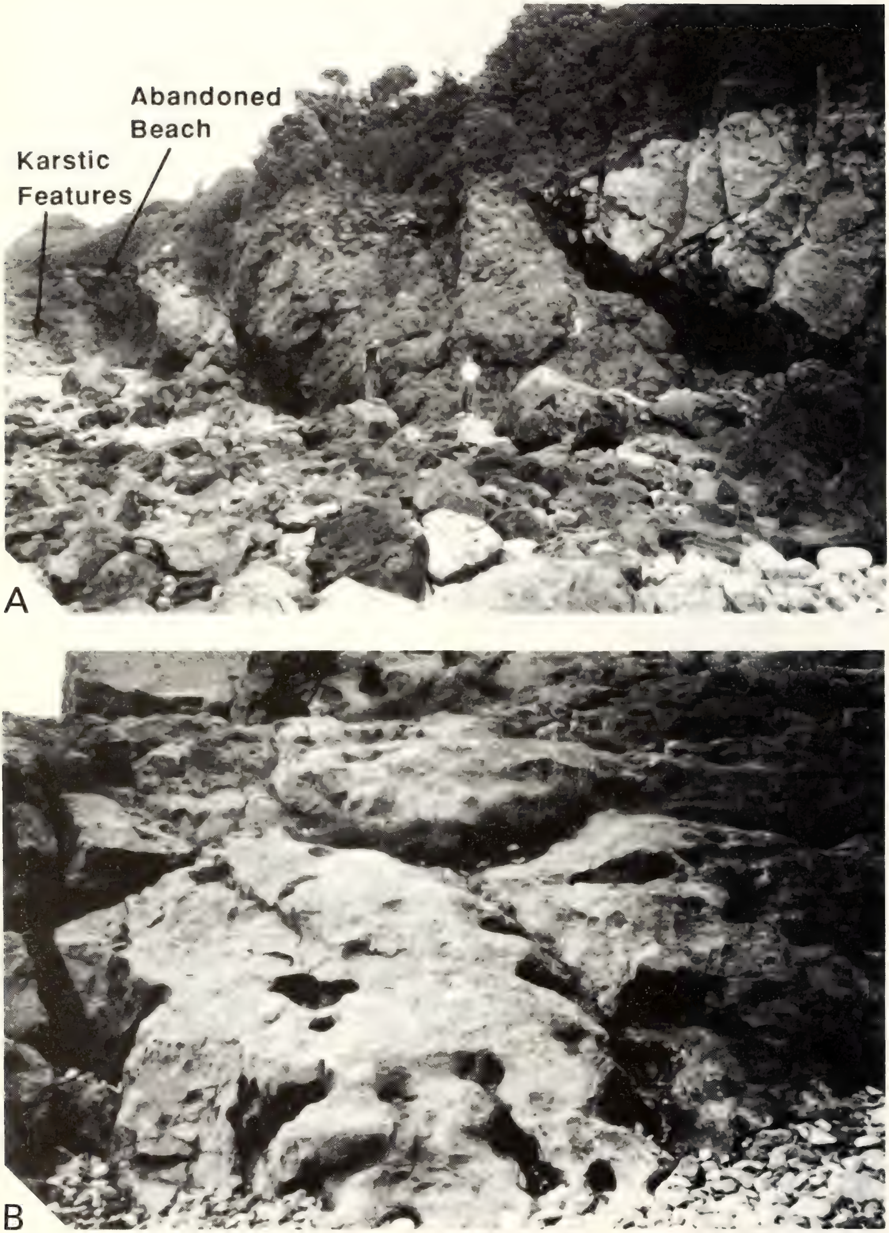

Abandoned Beach
Karstic Features
A
B

PLATE 1. Spring Cove, Weston-super-Mare. A, the main volcanic rocks, with the abandoned beach and karstic features arrowed. B, karstic features at the Mid-Avonian Break.

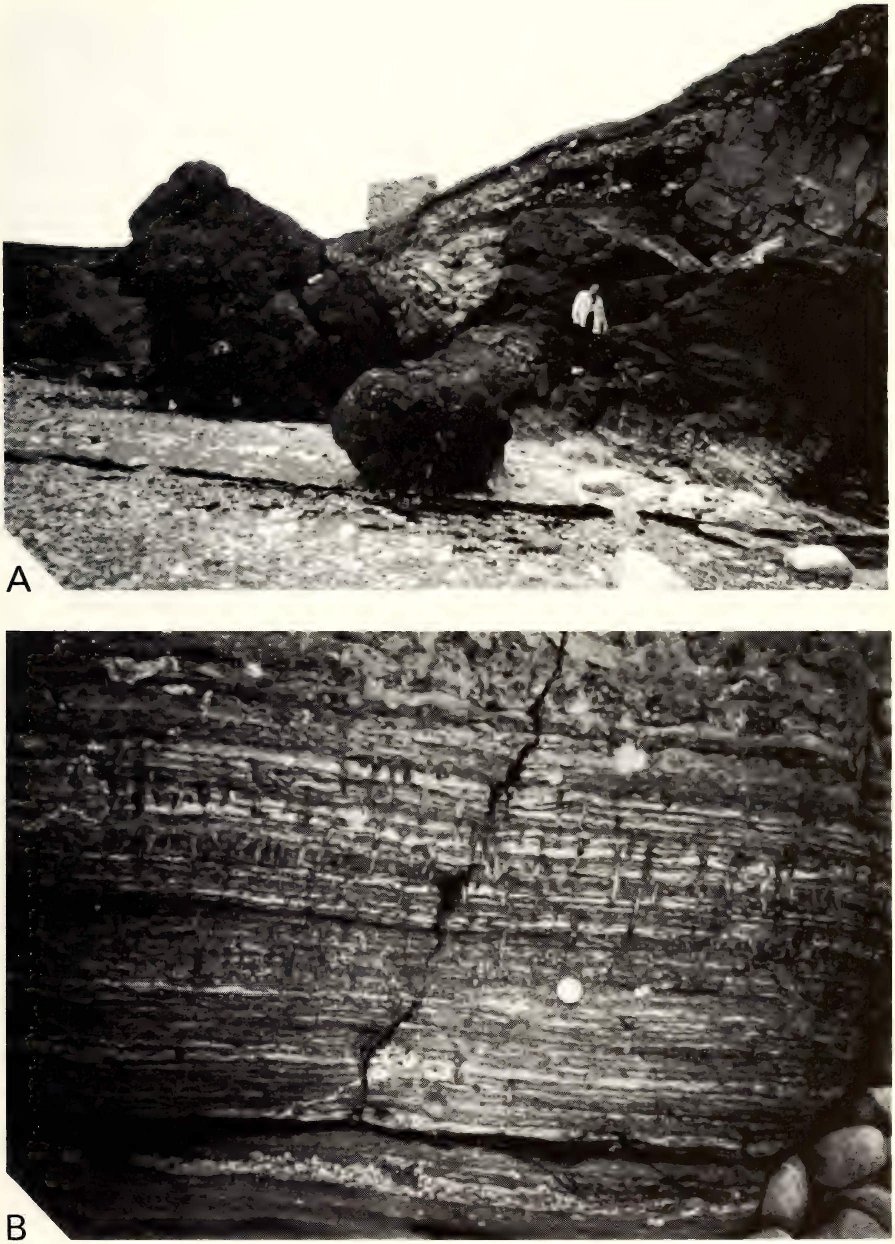


PLATE 2. Middle Hope. A, volcanic rocks and location of the raised beach at Swallow Cliff. B, the 'pipe rock' exposed in North Bay.

the Old Red Sandstone and at Woodhill Bay the Devonian fluvial conglomerates occur close to the famous calcrete deposits. These continental limestone horizons formed as a consequence of capillary rise in a semi-arid environment; where cracks occurred within the calcrete, nodular limestone developed in several places.

There are excellent examples of small-scale folds within the Lower Limestone Shales and Black Rock Group at the northern end of the Portishead promenade. In this region the strata have a different strike direction from that of the main Clevedon-Portishead ridge, due to the large thrust fault which passes through East Wood. Some of the plunging folds are almost symmetrical compared with the distinctly asymmetric fold shown in Plate 3B; in some cases the structure is emphasised by the differential erosion of the interbedded mudstones. At Battery Point itself, the Black Rock Limestone is not only highly fossiliferous but contains evidence of Z-shaped folds, implying that the main anticlinal structure was to the north (Williams & Hancock, 1977).

AUST

The Carboniferous Limestone seen at low tide in the Aust area is very different from that of the Clevedon/Weston-super-Mare region - e.g. during construction of the Severn-Wye cable tunnel, the presence of extensive silica within the Lower Dolomites caused such abrasion to a tunnelling machine that it was taken out of use. The Triassic section at Aust Cliff was once known as a classic geological exposure and many geologists came to examine the Mercia Mudstone and Penarth Group (Hamilton, 1977; Curtis, 1984). However, partly as a result of the reduction in cliff erosion following the construction of a roadway to the electricity pylon, the exposures have deteriorated and good examples of the Rhaetic Bone Bed or the pseudomorphs after salt are rarely found. The cyclic nature of the Mercia Mudstone (Curtis, 1984) is not easy to discern but the alabaster and the fibrous gypsum (satin spar) are well displayed - the latter having developed in discontinuities opened by hydraulic fracture (Shearman *et al.*, 1972). The main fault exposed in the cliff south of the M4 bridge provides an excellent example of faulted strata.

The cliffs at Aust formed an ideal site for the first motorway bridge across the River Severn, but the English Stones have been chosen as the best location for the new, wider bridge and associated embankments which will form the Second Severn Crossing, to be constructed in the 1990s. Here Triassic rocks consisting of both sandstones and interbedded sandstones/sandy silty marls unconformably overlie the Coal Measure strata which outcrop to the west of The Shoots. Indeed, in the boreholes for the new bridge next to The Shoots coal seams were met at a very shallow depth below the Triassic rock ledges.

Upstream of Aust the Mercia Mudstone is exposed in the Oldbury and Berkeley areas but north of Sharpness older Palaeozoic strata frequently form the bedrock of the estuary/river system. At first it seems surprising that adjacent to the Severn Estuary there are now no deposits between the Lower Lias period (*c.* 200 million years ago) and the Quaternary (*c.* 2 million years ago). It is likely that the later Jurassic and Cretaceous strata extended across the region but this cannot reliably be ascertained. It is interesting to note that some authors (e.g. Varney, 1921) have suggested that some of the intertidal river patterns in the area were developed by streams flowing from the Welsh Hills to the Solent.

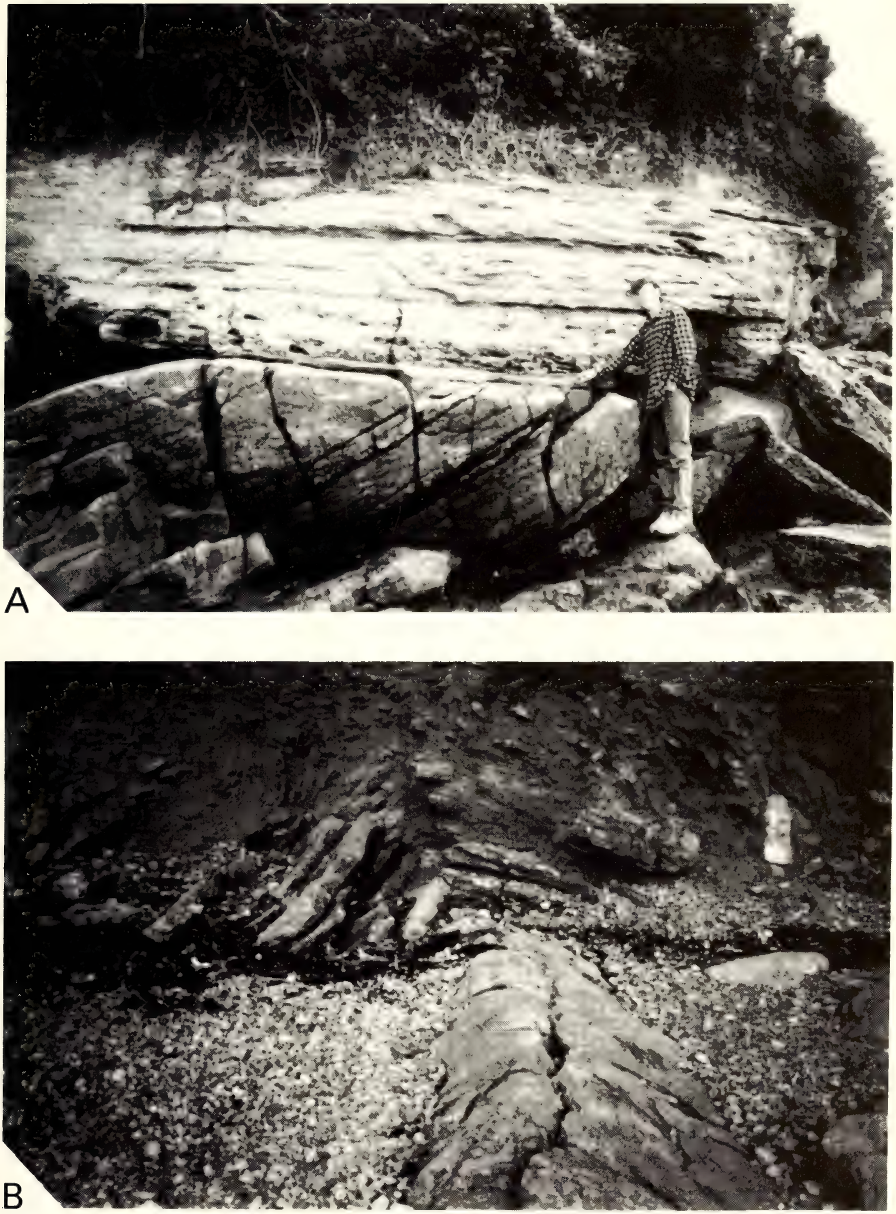


PLATE 3. A, the classic unconformity between the Old Red Sandstone and the Dolomitic Conglomerate at Redcliff Bay, south of Portishead. B, asymmetric folds in the Lower Limestone Shales at the northern end of the promenade at Portishead.

PLEISTOCENE GEOLOGY

It is unfortunate that the Quaternary literature contains such a confusing variation of stratigraphic terms. Although a number of the periods have now been defined relative to specific deposits on land, they have still not been conclusively dated or correlated with data from marine cores. It is a mystery to many that, despite modern scientific techniques such as radiocarbon dating and oxygen isotope work, these most recent geological deposits have caused such stratigraphic confusion. It must be appreciated, however, that the Quaternary includes both deposits which can be dated with relative precision and those which can only be given a wider 'geological' age. In addition, as many of the Quaternary deposits are found in isolation, their true stratigraphic correlation and age is not easy to establish. Table 1 has been included to facilitate a consideration of the relationship between the more common terminologies since the Pastonian.

TABLE 1. Quaternary stratigraphic terminology for the northern hemisphere, based on terrestrial evidence (after Lowe & Walker, 1987); cold periods in bold type.

Britain	*Northern Europe*	*European Alps*	*Central North America*
Flandrian	Holocene	Postglacial	Holocene
Devensian	**Weichselian**	**Wurm**	**Wisconsinan**
Ipswichian	Eemian	Riss-Wurm	Sangamon
Wolstonian	**Saalian**	**Riss**	**Illinoian**
Hoxnian	Holsteinian	Mindel-Riss	Yarmouthian
Anglian	**Elsterian**	**Mindel**	**Kansan**
Cromerian	Cromerian	Gunz-Mindel	Aftonian
Beestonian	**Menapian**	**Gunz**	**Nebraskan**
Pastonian	Waalian		

In the area of the Avon coast, glaciogenic deposits have been mapped on the top of Portishead Down at approximately 90 m OD, and very weathered till deposits (gumbotil) were exposed during trench excavations on the nearby site of the new Avon and Somerset Police Headquarters. Similar deposits were also identified during a soil survey on part of the Failand Ridge (Colbourne *et al.*, 1974). The M5 cutting through the Court Hill Col exposed a Quaternary valley infilled with approximately 25 m of glaciofluvial sands and gravels while the Tickenham Col is known to contain at least 15 m of similar material (Hawkins & Kellaway, 1971; Hawkins, 1972; Gilbertson & Hawkins, 1978*b*). A borehole in the East Clevedon Gap again indicated sands and gravels to a depth of –5 m OD, not dissimilar to the −12 m OD for the bedrock valley in the Avon Gorge at Clifton, but did not prove the Triassic deposits shown on the Bristol Special Geological Sheet. Extensive glacial and glaciofluvial deposits were exposed in the Kenn region during sewer trenching around 1970 (Gilbertson & Hawkins, 1978*a*). The only coastal area where good Pleistocene deposits exist is at Swallow Cliff on Middle Hope (ST 324 662), although poor exposures are visible on the Chepstow promontory. The abandoned beach section at Swallow Cliff has been described by Gilbertson & Hawkins (1977) and further data is presented by Briggs *et al.* (in press).

In the Chepstow promontory a glacial-type deposit can be seen at ST 551 905 which is shown on the geological map as part of the No. 2 Terrace. It is now known that several of the 'Terrace Deposits' shown on the geological map in the Chepstow area are actually gravelly silty clays, some containing clasts of over a ton in weight, while in the area to the west of Chepstow the No. 4 Terrace contains chalk-like material which has been identified as brucite. Hawkins (1968) drew attention to the fact that there is no direct relationship between the similarly numbered deposits mapped as terraces in the Chepstow area and those in the vicinity of Shirehampton/Portbury; thus Wills' (1938) account and sections for the Severn terraces in the Chepstow area are very misleading. The fact that the 'terraces' on both sides of the estuary have been proved to be partly of glaciogenic origin further confuses any relationship and inhibits direct interpretation/correlation from the geological maps.

It is not known when the Severn Estuary developed. It is assumed that the East Clevedon Gap and the Court Hill and Tickenham channels were eroded during the Anglian glaciation. At this time ice would have blocked the River Avon outlet through the Flax Bourton Gap, causing the diversion of the Bristol Avon and the creation of the Clifton Gorge, as suggested by Harmer (1907). Since the lowest proved bedrock level in the Flax Bourton Gap is still at about 44 m OD, at the time of the diversion the base level of the River Severn in the Clevedon area must have been in the order of 35 m OD. Whether the diversion occurred during the Anglian or an earlier glaciation is not known but it is unlikely to have been less than a half to three-quarters of a million years ago.

The glaciogenic deposits at Kenn are extremely complex (Gilbertson & Hawkins, 1978*a*). The fact that glaciofluvial outwash gravels occur to the east and tills to the west implies an easterly movement of the ice sheets from the western Bristol Channel/Celtic Sea area (Kellaway, 1971). The Kenn deposits may be Wolstonian in age but the fossiliferous sandy gravels mantling the deposits, described by Welch (1956) as being equivalent to the Burtle Beds, are considered to have formed during the sea level rise between the main Wolstonian glacial period and the ensuing Ipswichian interglacial (Andrews *et al.*, 1984). Passing through the Pleistocene glaciogenic deposits are channels containing a freshwater fauna characteristic of the Ipswichian (Gilbertson & Hawkins, 1978*a*).

Prior to the Wolstonian glaciation the Severn had clearly eroded a channel 1·5 km wide east of Severn Beach, with its base at about −9 m OD (Figure 4). At this time the Mounton Brook would have been creating a south-trending valley, the forerunner of the present Shoots. At the end of the Wolstonian, glaciofluvial deposits at least 8 m thick infilled the channel east of Severn Beach, blocking the main Severn valley which was then diverted westwards to enlarge the channel originated by the Mounton Brook. It is therefore believed that the present low water channel of The Shoots, which is only 0·5 km wide, probably did not exist until the Wolstonian, *c.*150,000 years ago. The nature of the old channel and the infill deposits was recorded by Lloyd Morgan when the approach cuttings to the Severn Tunnel were excavated (*in* Richardson, 1887). His long sections prove that the channel still contains a considerable thickness of glaciofluvial gravels with overlying sands, alluvium and peat horizons.

Macoma balthica from the sands overlying the gravels east of Severn Beach have been radiocarbon dated to 12,500 yrs BP. This date is unlikely to be reliable, however, and more probably represents an infinite age due to contamination and

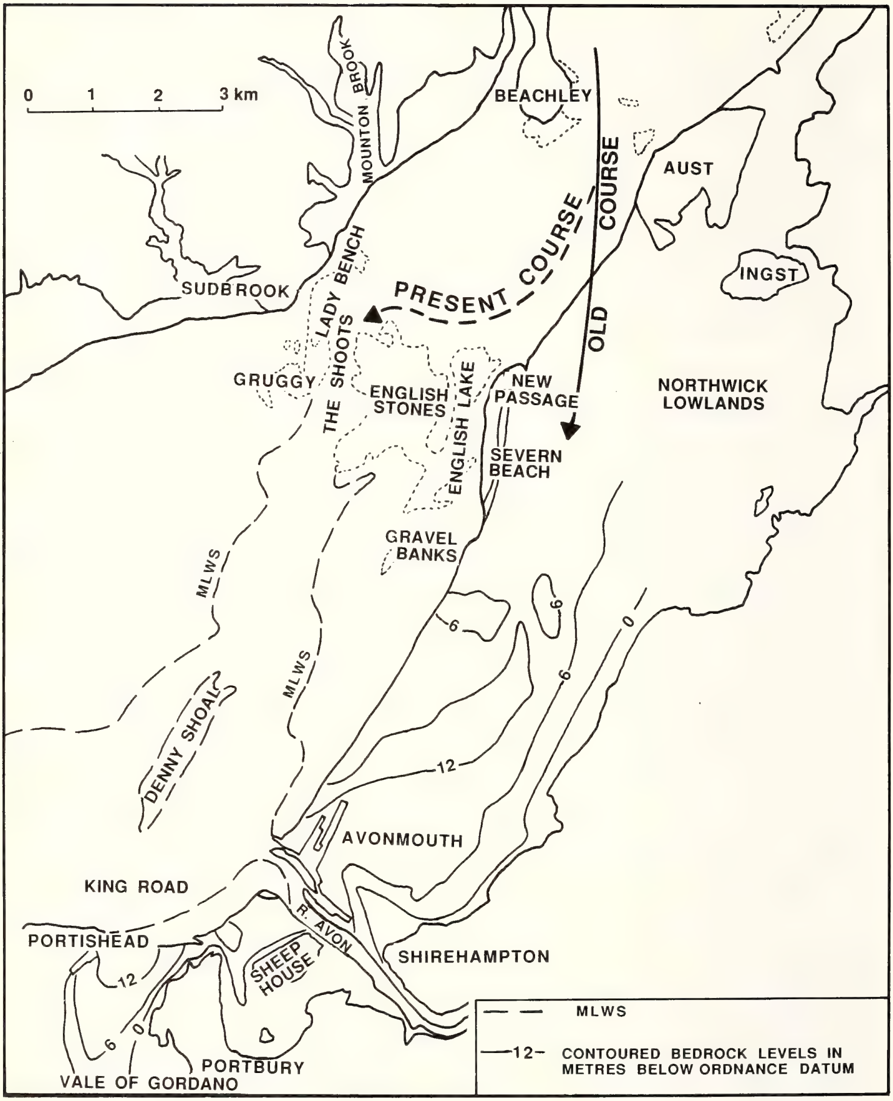

0 1 2 3 km
MOUNTON BROOK
BEACHLEY
SUDBROOK
LADY BENCH
THE SHOOTS
PRESENT COURSE
OLD COURSE
AUST
INGST
GRUGGY
ENGLISH STONES
ENGLISH LAKE
NEW PASSAGE
SEVERN BEACH
NORTHWICK LOWLANDS
GRAVEL BANKS
MLWS
MLWS
DENNY SHOAL
6
6
6
0
12
AVONMOUTH
KING ROAD
PORTISHEAD
R. AVON
SHEEP HOUSE
SHIREHAMPTON
12
6
0
PORTBURY
VALE OF GORDANO
MLWS
12 CONTOURED BEDROCK LEVELS IN METRES BELOW ORDNANCE DATUM

FIGURE 4. The old course of the River Severn below Severnside compared with the present coastline and showing the modern low water channel through The Shoots. After Hawkins (in press).

the limitations of the radiocarbon dating technique for old shell material. Similar sands which formed a sand bar across the Vale of Gordano were investigated by Jeffries *et al.* (1968) using hand auger borings. Inland of the sand bar they also proved the presence of a peat horizon containing material equating with Pollen

Zone III. More recently, Gilbertson *et al.* (1990) re-examined a vertical profile and obtained carbon dates on these peats.

During the Late Devensian glaciation only 23,000-14,000 years ago, ice from the Welsh massif reached at least to the Uskmouth area; indeed, ship-edge sampling in Newport Deep has suggested that the glacial advance may have extended several kilometres into the present Estuary. With the formation of large continental ice masses, sea level fell to in excess of 100 m below that at present. The floor of the Bristol Channel and Severn Estuary would therefore have been exposed, forming generally dry land crossed by various river channels. During this period of low base level The Shoots were eroded to a depth of *c.* –30 m OD, and in the King Road area off Portishead a slightly deeper channel was formed. In addition to the deep river channels, marine erosion created extensive platforms such as those beneath the Wentlooge and Caldicot Levels. Along the northern edge of the Caldicot Levels, beneath the large Llanwern Steelworks, there is a buried beach deposit from which shells have been obtained. Radiocarbon dating suggested an age of 25,000 yrs BP but, when amino acid racemization was undertaken shells from the same batch produced an AAR Zone II age, equivalent to the Ipswichian period (Andrews *et al.*, 1984).

During the Late Devensian low sea level, strong arctic winds would have been capable of transporting the recently exposed, unconsolidated, uncemented clays, silts and sands on the floor of the Bristol Channel/Severn Estuary. Much of this loessic-type material was deposited from the westerly winds as coversands, which explains the unusual thickness of the soils over the limestone terrain of the Mendip Hills (Findlay, 1965). An excellent example of these aeolian soils can be seen on the southern slopes of Brean Down. These have been described in detail by ApSimon *et al.* (1961), who discussed their researches undertaken in the 1950s. Of particular interest to many is the reindeer horizon within the basal part of the sands, indicating the temporary colder phase of the Loch Lomond Re-advance during the generally ameliorating climate towards the onset of the Holocene/Flandrian.

THE FLANDRIAN SEA LEVEL RISE

Although Horner (1816) referred to the relative change between land/sea level when discussing the submerged forests near Hinckley Point, the first significant contribution to sea level studies was by Godwin (1940). He examined pollen from a borehole profile at Swansea and observed that four of the six organic-rich horizons accumulated in Pollen Zone VIb. As the peat horizons containing Zone VIb pollen occurred over a vertical height of approximately –55 to –25 ft (*c.*–17 to –8 m) OD, Godwin concluded that at least 30 ft (9 m) of sediment must have accreted in the period represented by that Zone. In collaboration with Scandinavian workers, Godwin determined the length of Zone VIb to be approximately 600 years, ending about 8,000 years ago. He concluded that, as a consequence of the amelioration of the cold glacial climate and the melting of the major world ice sheets, the average rate of sea level rise was 1 ft (0·3 m) per twenty years (1·5 m per century). The resultant inundation Godwin named the Flandrian Transgression. The first sea level curve for the Severn Estuary (Figure 5; from Hawkins, 1971) was subsequently supported by other workers, including Kidson & Heyworth (1973) and Devoy (1977). A major problem in producing a sea level curve for the Severn Estuary is its particularly large tidal range (Figure 6A). The high water

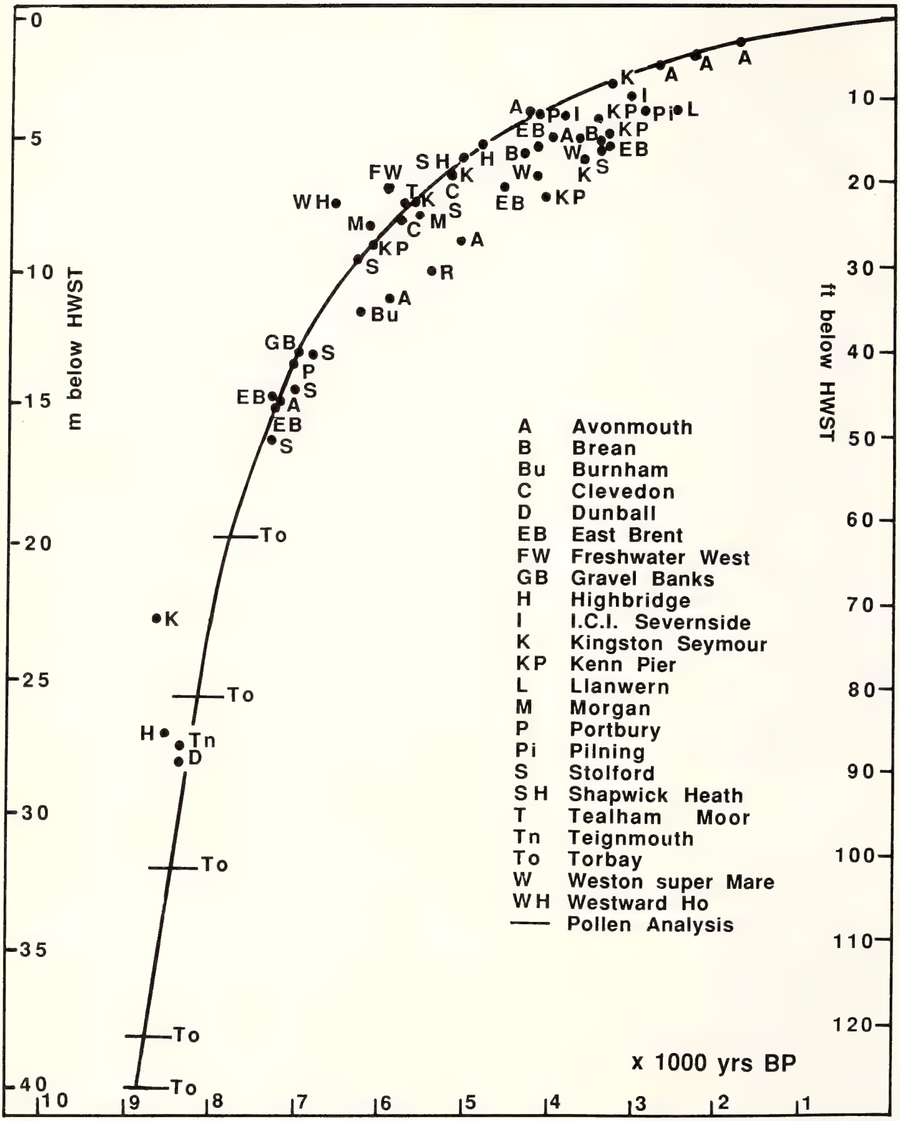


FIGURE 5. Sea level curve for the Severn Estuary. After Hawkins (1971).

astronomical tide (HAT) controls the ultimate height to which sediment accretion can take place and, as seen in Figure 6B, both this and the mean high water spring tide (MHWS) increase up the Bristol Channel/Severn Estuary region. The botanical environment most likely to produce sufficient vegetation to form a datable peat

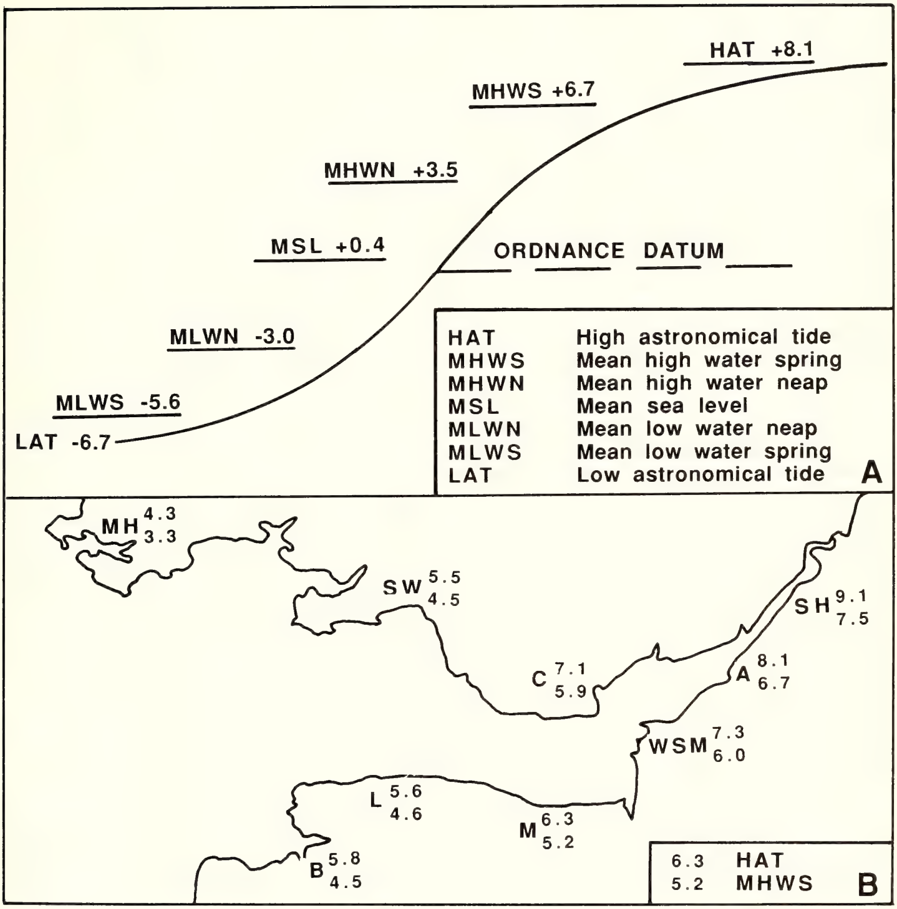

HAT +8.1
MHWS +6.7
MHWN +3.5
MSL +0.4
ORDNANCE DATUM
MLWN -3.0
MLWS -5.6
LAT -6.7
HAT High astronomical tide
MHWS Mean high water spring
MHWN Mean high water neap
MSL Mean sea level
MLWN Mean low water neap
MLWS Mean low water spring
LAT Low astronomical tide
A
MH 4.3 3.3
SW 5.5 4.5
C 7.1 5.9
SH 9.1 7.5
A 8.1 6.7
WSM 7.3 6.0
L 5.6 4.6
M 6.3 5.2
B 5.8 4.5
6.3 HAT
5.2 MHWS
B

FIGURE 6. A, levels of the various tidal stages at Avonmouth (Admiralty Tide Tables, 1991). B, increase in height of the HAT (upper figure) and the MHWST (lower figure) for stations around the Bristol Channel/Severn Estuary: MH, Milford Haven; SW, Swansea; C, Cardiff; SH, Sharpness; A, Aust; WSM, Weston-super-Mare; M, Minehead; L, Lynton; and B, Bideford.

horizon is at or above MHWS. It should be noted, however, that vegetation is now found below this level since the introduction of grasses tolerant of saline water. These bind the estuarine muds and encourage accretion in areas where erosion had become a serious problem (see Martin, 1992). Reference to the Admiralty Tide Tables shows that the level of MHWS at Milford Haven is +3·3 m, while at Severn Beach the same botanical conditions pertain at *c*.+7 m OD. Rather than using mean sea level or Ordnance Datum, therefore, Hawkins (1971) related his sea level curve to the MHWS datum (i.e. approaching the level of the wharflands).

In deciding how to draw the sea level curve relative to the depth/age points available, it was important to take into account the potential consolidation of organic-rich horizons, hence the curve was placed through those points where the vegetation grew on rock or gravel deposits. This line was seen to pass through the base of the peat horizons identified in the literature and resulted in a smooth curve, closely resembling that of Jelgersma (1961) for The Netherlands and supporting the fast eustatic rise of Godwin's Flandrian Transgression. Figure 5 shows that many points lie to the right of the curve; hence, although those for the base of the 1·1 m thick peat at Ordnance Datum (dated 6,100 ± 120 yrs BP) plot on the line, the top of the band (2,000 years younger) is 3-4 m 'below' the eustatic curve. Hawkins (1984) considered that this was due to consolidation, as a result of the increased loading on the peat horizon produced by subsequent accretion of sediment.

Following the excavation of the Huntspill drainage ditch, Godwin (1943) described the palynology and archaeology along the line of this major drainage channel. Unfortunately a mistake occurred in the level recorded for the Romano-British remains found on peat hummocks along the line of the Huntspill Channel. Rather than being 3 m deep as indicated in Godwin's figure, the deposits are *c.* 3 ft (1 m) below the present ground surface (see Hawkins, 1971). Godwin (1943) also noted that at Combwich "what appears to be the same upper clay at a height of 21 ft OD, has a Romano British occupation at or close beneath its surface", so he speculated that between 250 AD and 400 AD the sea level rose by some 10 ft (3 m), which he referred to as the Romano-British Transgression. Subsequent research by Hawkins (1971) showed that there were no buried soil horizons consistent with a Roman landscape at about 10 ft (3 m) below the present surface as implied by Godwin. Also Murray & Hawkins (1976), studying the microfauna of the estuarine alluvium, failed to find any palaeontological break above the upper uneroded peat horizon which had accumulated at least 1,000 years before the Roman occupation of Britain. It is unfortunate that an error in measurement or recording led Godwin to postulate a Romano-British Transgression and that before being disproved it was referred to in the geological and soils literature (e.g. Green & Welch, 1965, p. 121).

Besides the extensive Roman remains found along the Huntspill drainage ditch at approximately 1 m below ground level, vast numbers of artefacts were discovered during the construction of the M5 motorway and by Lilly & Usher (1972) in the Kenn area. Most of the sea walls which restrict the tidal inundation of the Levels were not built until the 14th to 17th centuries, so the metre of sediment must clearly have accumulated during the *c.* 1,000 years between the end of the Roman period and the construction of the sea walls. Averaged, this would represent a sea level rise of about 1 mm per year and, including the period since the construction of the sea walls, would imply a sea level rise of 1·25-1·5 m – close to the 1·3 m suggested by Allen (1991) for the inner Severn Estuary.

Detailed surveys for the construction of the West Docks showed the height of the St George's Wharf area to be 0·5-1 m above that behind the sea walls (Figure 7). A similar situation occurs in a number of areas in the Severn Beach and Aust regions where the land beyond the sea wall lies up to 0·75 m above the protected farmland (Hawkins, 1984). However, it is important to appreciate that this rise in land level outside the sea defences of up to a metre within approximately the last 500 years does not necessarily reflect a 2 mm per year eustatic rise. The artificial restriction of the natural inundation of the wharflands would have resulted in an increased tidal range within the Estuary; the effect would have been exacerbated as sea walls were constructed progressively towards the mudflats.

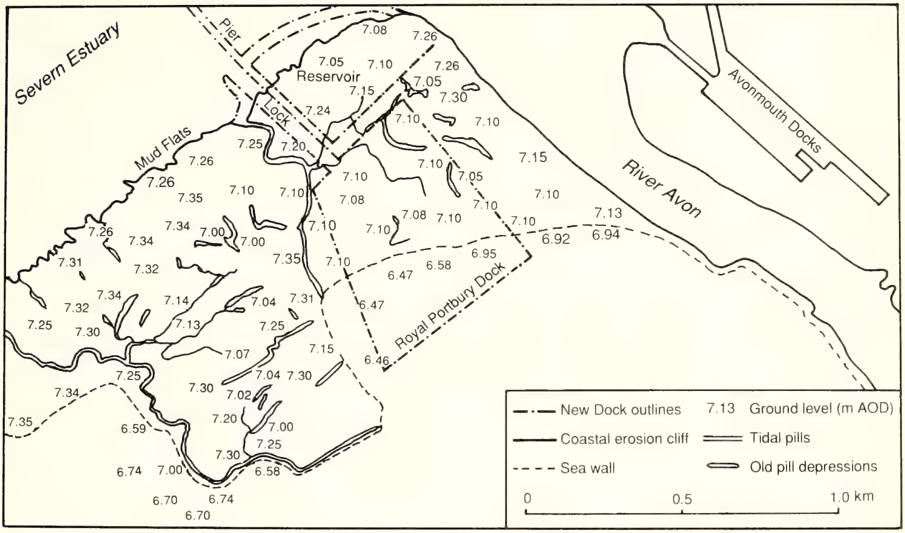

Severn Estuary
Pier
Lock
Reservoir
Mud Flats
River Avon
Avonmouth Docks
Royal Portbury Dock
7.08
7.26
7.05
7.10
7.26
7.05
7.15
7.30
7.24
7.10
7.10
7.25
7.20
7.15
7.26
7.10
7.10
7.05
7.26
7.35
7.10
7.10
7.08
7.10
7.10
7.13
7.26
7.34
7.00
7.00
7.10
7.10
7.08
7.10
6.92
6.94
7.34
7.31
7.32
7.35
7.10
6.95
6.58
6.47
7.34
7.14
7.04
7.31
6.47
7.32
7.25
7.30
7.13
7.25
7.07
7.15
6.46
7.25
7.04
7.30
7.34
7.30
7.02
7.35
6.59
7.20
7.00
7.25
7.30
6.74
7.00
6.58
6.70
6.74
6.70
New Dock outlines
Coastal erosion cliff
Sea wall
7.13 Ground level (m AOD)
Tidal pills
Old pill depressions
0
0.5
1.0 km

FIGURE 7. Tidal pills and ground level heights relative to Ordnance Datum for the area now occupied by Royal Portbury/West Dock, both inside and outside the sea walls.

On the basis of computations from tide gauge data, Rossiter (1972) suggested that the rate of sea level rise at Avonmouth was 2·4 mm per year. This is much faster than the average rate since the Roman period; the difference may indicate that the eustatic rise accelerated during the industrial revolution, or it may represent a misconstruction of sea level rise from the tide gauge data. With the present concern over possible sea level changes related to the greenhouse effect, it is interesting to note that Gornitz & Lebedeff (1987) and Barnett (1988) also used tide gauge data and concluded that since 1880 the rate of rise has been 1-1·2 mm per year. Computer models are currently being used to predict high, best and low estimates of sea level rise to the years 2030 and 2100. Both Clayton (1990) and Warrick & Oerlemans (1990) have best estimates of 4·1 mm per year over the 40 year period. Their low estimates vary between 0·65 mm and 1·9 mm, and their high estimates between 9·1 mm and 6·4 mm per year respectively. Most authors draw attention to the inadequacies of the current information on which such estimates must be based and therefore the care with which their predictions must be used. This is particularly apposite in view of the dramatic or even scare-mongering views sometimes expressed.

THE SEDIMENTS AND THEIR ENGINEERING SIGNIFICANCE

The Holocene deposits which form most of the Avon coastline infill a deep, broad channel eroded at the time of low sea level during the Late Devensian; a schematic cross-section is given in Figure 8. Marine coring in Torbay has recovered a number of peat samples from the bedrock subsurface which were studied by Clarke (1970) in Godwin's laboratory at Cambridge University. These salt marsh peats were interpreted as having accumulated at a time when rising sea level induced very damp or waterlogged conditions and all but one were assigned to Pollen Zone VIb. Similar basal peats are common in many parts of the Somerset Levels and Severn Estuary regions such as Dunball, Highbridge and Kingston Seymour. At Dunball, a 0·3 m thick peat band, dated at 8,360 ± 140 yrs BP, overlies a thin basal gravel at 88 ft (27 m) below the ground surface, indicating that the inundation and resultant Holocene sedimentation in the area now known as the Somerset Levels had not begun much before 8,000 years ago.

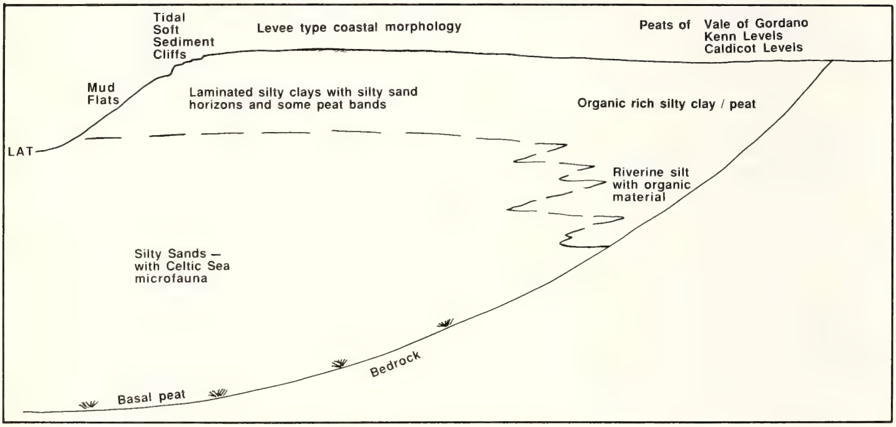

Tidal Soft Sediment Cliffs
Levee type coastal morphology
Peats of Vale of Gordano Kenn Levels Caldicot Levels
Mud Flats
Laminated silty clays with silty sand horizons and some peat bands
Organic rich silty clay / peat
LAT
Riverine silt with organic material
Silty Sands – with Celtic Sea microfauna
Bedrock
Basal peat

FIGURE 8. Schematic cross-section of the Flandrian deposits of the coastal lowlands.

Examination of over 60,000 foraminiferids from various parts of the Estuary up to Oldbury (Murray & Hawkins, 1976) showed that the deeper sediments contained microfossils more typical of the western marine regions rather than indigenous fauna. In material recovered from a borehole at Watchfield, approximately 17 m of silty sand contained microfossils similar to those from the present Celtic Sea. Consequently it is clear that sufficiently high energy conditions accompanied the fast Flandrian Transgression to transport silty sandy sediment eastwards into the area of the Somerset Levels and Severn Estuary. From a number of borehole records it is known that these sands accreted up to a level of about 8 m below the present ground surface and it is reasonable to assume that they had a surface morphology similar to that existing today in the area of the Welsh Grounds. Such sands are rarely visible now along the coast, but in the Portishead area they are exposed during the spring and autumn low astronomical tides.

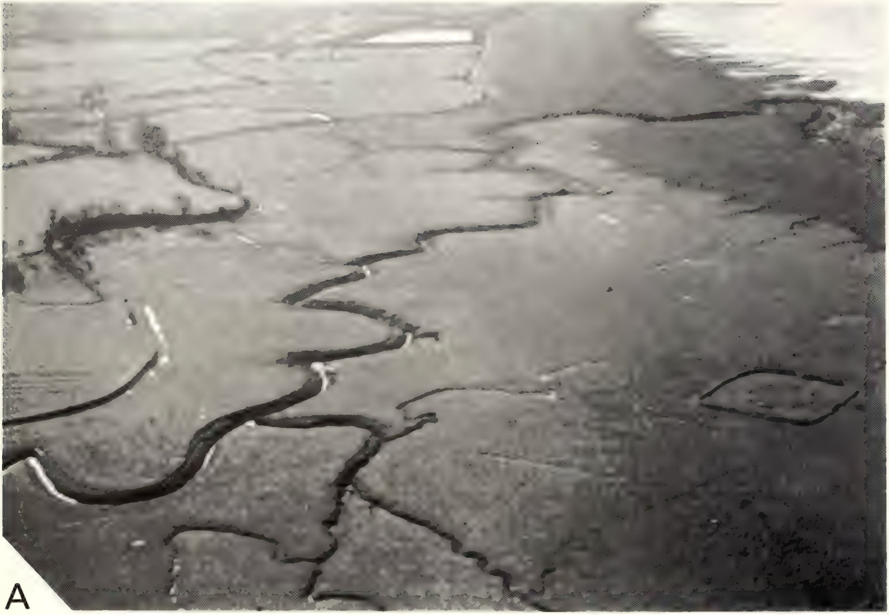
As the rate of the Flandrian eustatic rise declined about 7,000 years ago, lower energy regimes pertained in areas such as the Severn Estuary. The microfossil study indicated a progressive increase in indigenous species and the sediment type became dominated by silts and clays. During storms, however, high energy conditions resulted in the accreting mudflats being veneered with silty sands transported landwards from the lower tidal channel, thus creating a laminated alluvial sequence. In places, extensive disturbance of the laminae by burrowing and grazing animals (dominantly *Macoma balthica*, *Hydrobia* and *Arenicola*; see Boyden & Little, 1973 and Gilbertson & Hawkins, 1985) frequently destroyed the laminations. Whilst these sediments may retain the same particle grading as the laminated material, therefore, their original structure may have been totally destroyed (Hawkins, 1984). Laminated sediments are seen in the soft sediment cliffs at the edge of the wharflands, both between Portishead and Aust and in the Sudbrook area to the west of the Estuary.

In the Sudbrook area the soft sediment cliff is of particular interest, since it has clearly developed from flood tide erosion as the flood waters passed between the Sudbrook Triassic cliff line and Charlston Rock. At its maximum the cliff is up to 1·3 m high, yet only 200 m to the north and south the cliffs are rarely more than 0·3 m and eventually die out (Hawkins, 1979). A similar situation is created by the ebb tide where the main Severn flow is deflected by the Chepstow Peninsula and erodes the soft sediments to produce a pronounced cliff line between Aust and Severn Beach. This feature, with a height of about 2 m, is clearly the latest of a number of soft sediment cliffs (close examination of the wharflands reveals up to five such cliff lines). Allen (1992) discusses the formation of similar features further up the Estuary.

The soft sediment cliff lines are good areas in which to examine the alluvial profile and it can be seen that only limited vegetation occurs until close to the present land surface. Here the wharflands are typically developing a salt marsh vegetation which, if subsequently inundated, would form the peat horizons commonly found in the coastal alluvial deposits. Away from the estuarine margins, fresh-water peats frequently dominated by *Phragmites* have accumulated, while in areas such as Shapwick in Somerset the *Sphagnum* peats formed independently of the contemporary ground water conditions. In the Caldicot Levels, Kenn Moor and the Vale of Gordano, ground level in the inland peat regions is now 1-2 m lower than the equivalent level along the coastal margin. It is not known whether this is due to consolidation of the organic-rich peat deposits following drainage or whether it represents a levee-type deposition.

An important consequence of the presence of a coastal levee-type morphology along the estuarine margin is that flood waters inundating the salt marshes at HAT could not return to the Estuary unless there was a series of tidal pill channels. In the area now occupied by the Royal Portbury Dock (sometimes referred to as West Dock), such channels were well developed across the salt marsh (Figure 7; Plate 4A). Some of these channels were about 2 m deep and exposed an organic-rich topsoil overlying a laminated material. In other areas, however, the pill system has clearly become less effective and organic-rich sediments have begun to accumulate; this will, with time, result in the formation of localised linear peat deposits (Plate 4B).

Inland of the sea walls, the old channels are now frequently difficult to distinguish. In some cases they have been straightened by man and the only way of detecting them is by the use of infra red/false colour photography or the very careful examination of trial trenches. The largest channel known was first appreciated in 1960 when flood waters were photographed in the Brent area (Williams, 1970). Subsequently, trial pitting and laboratory testing by the author have shown conclusively that this was an old river system, probably related to an early course of the River Brue. Such channels also clearly existed at previous levels of sediment accretion, as shown in the sections produced for the eastern side of the Severn Tunnel cutting (Lloyd Morgan *in* Richardson, 1887). What appear in those sections to be four distinct pills have been shown by Hawkins (1984) to represent a meandering channel pattern with a tributary system.



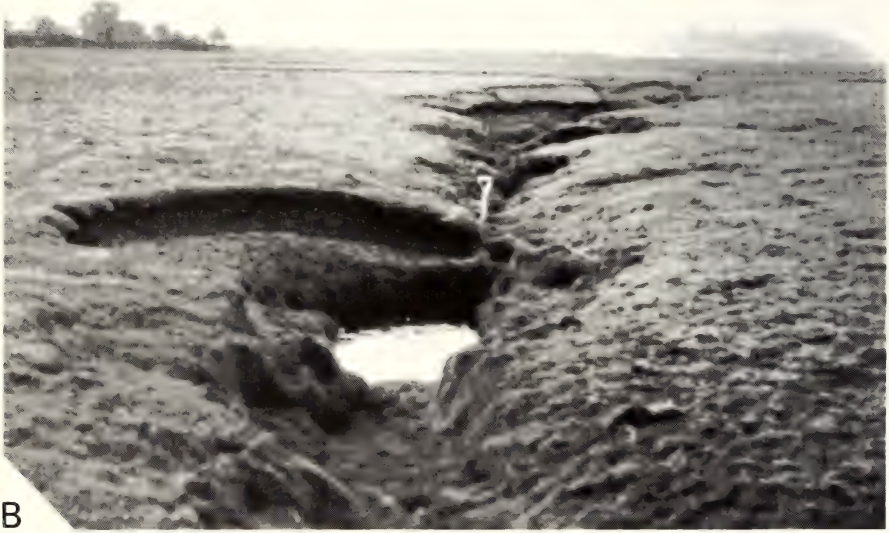


PLATE 4. A, tidal pills across the wharflands between Avonmouth and Portishead, since destroyed by the construction of the Royal Portbury/West Dock. B, an almost-infilled tidal pill with organic-rich contents which would eventually produce a 'ribbon' of peat.

The type of sediment is of particular importance to the engineer wishing to construct houses, roads, etc. across the estuarine levels. As a result of the slow rate of accretion in the last 3,000 years and the 4 m difference between HAT and MHWN tide in the Severn Estuary, the natural level of the fully saturated ground would have been 2 - 3 m below the surface prior to the creation of an artificially high ground water level for the benefit of the dairy industry (Hawkins *et al.*, 1989). Weathering causes the oxidation of ferrous ions within the silty clays, and their partial re-mobilisation results in point-contact cementation of the soil particles. Also, calcium carbonate leached from dissolved foraminiferid shells has enhanced sediment strength such that the upper horizons of the estuarine alluvium are invariably firm to stiff. These upper zones are referred to by engineers as the over-consolidated surface layers or desiccated crust, in contrast to the moist, very soft to soft, normally consolidated deposits below ground water level. This naturally increased strength of the near surface deposits allows the construction of two-storey houses and highways across the coastal levels. With buildings of three or more storeys the loads may become so high that piling is necessary, although where the desiccated crust is thick it may be possible to use a buoyancy raft to save the cost of expensive piled foundations. Before a buoyancy raft can be recommended, however, it is essential to ascertain that no infilled channels occur as these may lead to differential settlement and structural distress to the buildings.

In the 1950s many engineers, using standard consolidation (oedometer) testing apparatus, believed that when motorways were constructed the rate of consolidation would be so slow that considerable long-term maintenance costs would be incurred. At that time it was not appreciated that the upper sediments were laminated and that the silty sands, with permeabilities up to three orders greater than the silty clays, would facilitate lateral pore pressure dissipation. In the trial embankment at Avonmouth in the 1960s, the pore pressures dissipated within 18 months of construction, implying that consolidation had effectively ceased. The Over Embankment at Gloucester, however, was constructed on mainly riverine alluvium where the laminated estuarine soils did not exist. Here only half the induced pore pressures had been relieved after three years (Hawkins, 1976). In such situations the long term maintenance costs of the roadways is considerably greater. When travelling on the M5 motorway south of the Mendips it is interesting to note that differential settlements have not resulted in excessive undulations in the highway. In some places, however, hard spots have been produced where culverts have been piled, and some instances of increased settlement probably indicate where the motorway crosses old infilled channels.

Probably one of the biggest changes to the Avon coast has been caused by the development of the Royal Edward Docks at Avonmouth in the nineteenth century and the Royal Portbury Dock in the twentieth century. The modifications brought about by these large engineering schemes are highlighted in Figure 9, which compares the coastal area as shown on the Admiralty Charts between 1839 and 1989. As can be seen, the river originally flowed around Dunball Island at the mouth of the River Avon,but this feature was excavated during the construction of the Royal Edward Dock (Hawkins, 1984). Subsequently, further development extended into the intertidal wharflands west of the River Avon (Plate 4A; Figure 7) to form the Royal Portbury Dock.

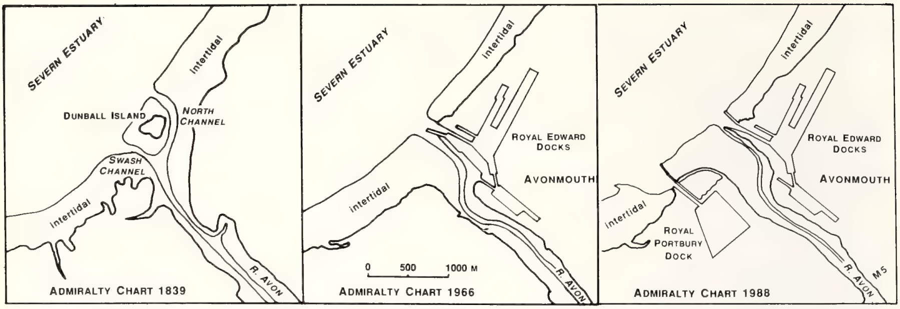

Severn Estuary
intertidal
Dunball Island
North Channel
Swash Channel
intertidal
R. Avon
Admiralty Chart 1839
Severn Estuary
intertidal
Royal Edward Docks
Avonmouth
intertidal
0 500 1000 m
R. Avon
Admiralty Chart 1966
Severn Estuary
intertidal
Royal Edward Docks
Avonmouth
intertidal
Royal Portbury Dock
R. Avon
M5
Admiralty Chart 1988

FIGURE 9. Changes at the mouth of the River Avon due to the construction of the dock system.

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THE POST-GLACIAL GEOLOGY AND GEOARCHAEOLOGY OF THE AVON WETLANDS

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ABSTRACT

The sediments that accumulated during post-glacial times on the margins of the Severn Estuary bury a valley-within-a-valley which had been shaped during the Pleistocene by fluvial, marine and periglacial processes. The deposits arose during a major marine transgression, which is continuing today, and record a variety of depositional environments, especially high tidal mudflats and marshes. Human activity has increasingly influenced the character of these marginal wetlands, with extensive reclamation occuring during and since the Roman period. Estuary-wide fluctuations apparently in wind-wave climate over recent centuries have led to major movements of the high-tide shoreline, as erosional and accretionary regimes alternated on the mudflats and marshes, and some reclaimed lands have been lost.

INTRODUCTION

The Severn Estuary, overlooked by the high ground of the Mendip Hills, the Forest of Dean and the Cotswold Hills, is not only an inspirational place but also an area of considerable geological and geoarchaeological interest and importance. It is one of the most substantial and varied estuaries in Britain, and is affected by some of the largest tides in the world, making it an appealing natural laboratory for the study of many sedimentary processes. Moreover, its post-glacial (Flandrian) history is there for the reading in what are arguably the most extensive and complete exposures of shallow-marine sediments of this age anywhere in the British Isles. Because it intrudes deeply into the English Midlands, providing with its rivers a major link to the western seas, the Severn Estuary and its immediate surroundings have long been the scene of varied and at times intense human activity. Research on the Severn Estuary and its post-glacial history has not yet advanced far, but sufficient has become clear to justify the present introductory outline.

THE CONTEMPORARY SEVERN ESTUARY

The modern Estuary (Figure 1*a*, *b*), its banks rising as high as *c*. 10 m OD, lies in the broad Severn Vale, underlain chiefly by soft, Triassic to early Jurassic mudrocks, with here and there the more resistant Silurian, Old Red Sandstone (Devonian) and Carboniferous beds (Evans, 1982; Hawkins 1992). The high ground overlooking the Estuary is formed of Carboniferous rocks in the Mendip Hills and Bristol area, of resistant mid-Jurassic limestones in the Cotswold Hills, and of Old Red Sandstone and Carboniferous strata in the Forest of Dean. Although many of these beds are widely exposed on cliffs and intertidal rock platforms, making the Estuary a partly rock-bound system, outcrops of post-glacial, largely estuarine alluvium fringe great stretches of the shoreline (Figure 1*b*). These deposits, which

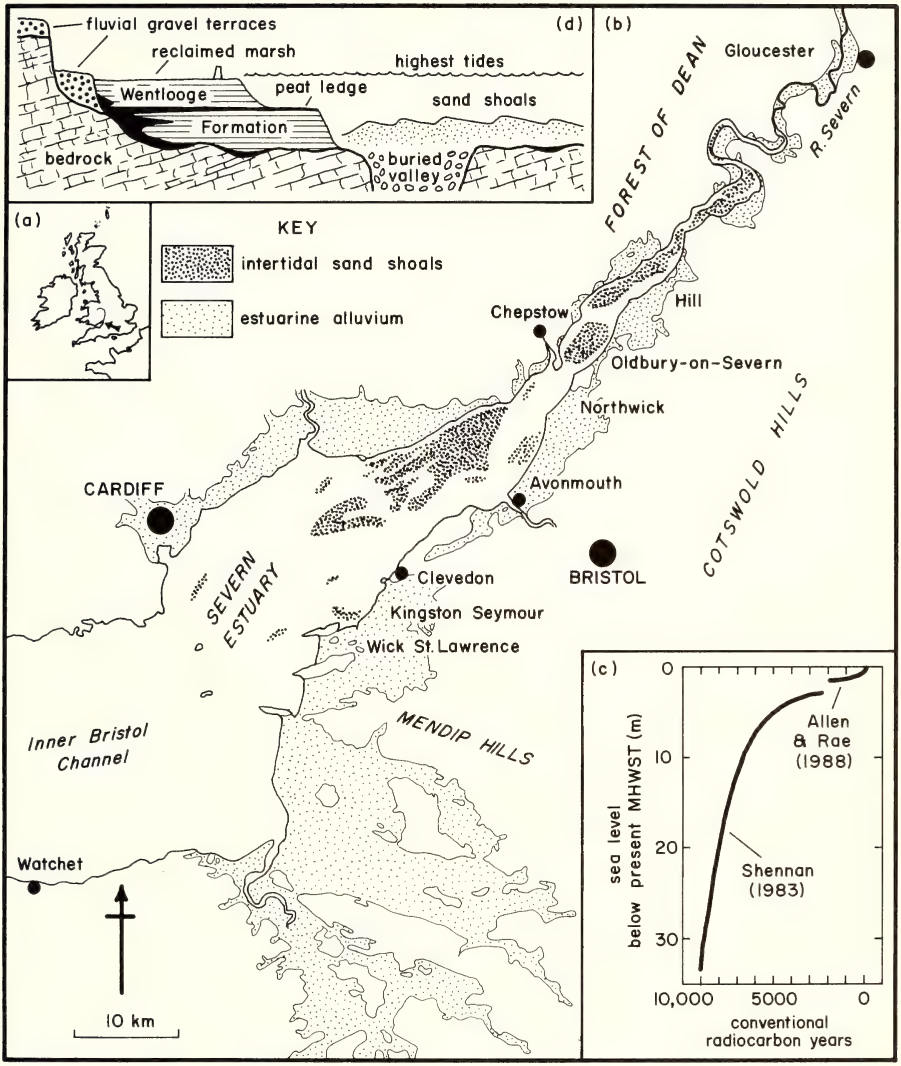
fluvial gravel terraces
(d)
reclaimed marsh
highest tides
Wentlooge
peat ledge
sand shoals
Formation
bedrock
buried valley
(b)
Gloucester
FOREST OF DEAN
R. Severn
(a)
KEY
intertidal sand shoals
estuarine alluvium
Chepstow
Hill
Oldbury-on-Severn
Northwick
COTSWOLD HILLS
Avonmouth
CARDIFF
BRISTOL
Clevedon
SEVERN ESTUARY
Kingston Seymour
Wick St. Lawrence
MENDIP HILLS
Inner Bristol Channel
Watchet
10 km
(c)
sea level below present MHWST (m)
0
10
20
30
Allen & Rae (1988)
Shennan (1983)
10,000
5000
0
conventional radiocarbon years

FIGURE 1. Inner Bristol Channel and Severn Estuary. *a*, *b*, sedimentary features; *c*, post-glacial sea-level rise; and *d*, post-glacial geology.

average 10-15 m thick in many places, underlie a total of about 840 km^2 and amount to some 8 km^3 of mainly fine grained mineral sediment.

A strongly macrotidal regime (Davies, 1964) characterizes the Severn Estuary. The astronomical tide at Avonmouth (Hydrographer of the Navy, 1990) has an extreme range of 14·8 m, mean spring and mean neap ranges respectively of 12·3 m and

6·5 m, mean high-water springs rising to 13·2 m above tidal datum, and mean high-water neaps attaining 10·0 m. The mean high-water of spring tides reaches an altitude of about 6 m OD in the inner Bristol Channel, rising smoothly to a maximum of about 8·5 m OD some 10 km downstream from Gloucester. The tidal currents are correspondingly vigorous (Hamilton, 1979; Crickmore, 1982; Uncles, 1982, 1984; Stephens, 1986; Uncles *et al.,* 1986). The setting, aspect and size of the Estuary ensure that substantial storm surges (Lennon, 1963*a*, *b*) and powerful waves (Shuttler, 1982; Smith, 1983; Cook & Prior, 1987) at times arise.

The Severn Estuary and inner Bristol Channel are notoriously turbid and complex in their fine-sediment regime (Hydraulics Research Station, 1981; Kirby & Parker, 1982, 1983; Kirby, 1986). Fine sediment reaches the system from a range of onshore and marine sources (Allen 1990*a*), but most, amounting to the order of 10^6 t annually, is introduced by the rivers, predominantly the Severn, Wye and Bristol Avon (Collins, 1983). The sandy deposits, however, carry an unmistakably metamorphic mineralogical signature (Barrie, 1980*a*, *b*, 1981), recognizable upstream at least to near Gloucester, despite much tidal reworking and sorting. These sediments may have been carried up into the Estuary largely from glacial and proglacial sources located in the outer Bristol Channel and Celtic Sea.

Although widening south-westward before joining the head of the west-facing Bristol Channel (Figure 1*a*, *b*), the Severn Estuary lacks the perfect funnel shape of so-called coastal plain estuaries. It is divisible (see also Hamilton, 1979) into three parts. The inner Estuary, extending 15-20 km downstream from Gloucester, is characterized by a relatively narrow but boldly meandering channel. The upper banks are muddy and fringed by tidal marshes, but sand shoals, exposed at low water, are chiefly confined to the inner shores of the meanders. In the middle Estuary, ranging downstream to the Chepstow narrows, the sand shoals are mainly detached from the banks, which present broad high tidal mudflats, with a rich if restricted invertebrate infauna (Boyden & Little, 1973), as well as fringing marshes (Smith, 1979; Allen & Rae, 1987). Substantial intertidal shoals and sheets of sand decorated with dunes and other large bedforms typify the outer Estuary (Harris & Collins, 1985), where again there are fringing mudflats and marshes.

POST-GLACIAL MOVEMENT OF SEA-LEVEL

By radiocarbon dating peat, timber and wooden artefacts from the Severn Estuary and inner Bristol Channel (Heyworth & Kidson, 1982; Shennan, 1983), and by measuring marsh accretion across archaeologically or otherwise dated seabanks on the reclaimed tidal wetlands (Allen & Rae, 1988; Allen, 1991*a*), it is possible to chart in the area (Figure 1*c*) the general movement of relative sea-level (approximately mean high-water of spring tides) during post-glacial times. Relative sea-level, ascending at first rapidly and then more gradually, has risen by approximately 35 m in the last 9,000 conventional radiocarbon years. Consequently the strandline has moved rapidly inland during this period across the comparatively gentle topography of the Bristol Channel and Severn Vale (Hawkins, 1971). One product of this major transgression is the substantial outcrop of estuarine alluvium shown in Figure 1*b*, accumulated largely on high tidal mudflats and tidally influenced marshes. The rise of the sea is continuing, however, at an annual rate approaching 2 mm on tide-gauge evidence (Woodworth, 1987, 1990), and is driving the Severn Estuary still further north-eastward (Allen, 1990*a*). A telling

PLATE 1. Junction between three ice-wedge casts affecting Triassic mudstones, Hills Flats, Avon. Trowel for scale.

proof is afforded by the erosively trimmed exposures of estuarine alluvium to be found widely distributed in the modern intertidal zone of the Estuary.

THE BEDROCK SURFACE

The bedrock surface in the area of the Severn Estuary may aptly be described topographically as a valley-within-a-valley (Figure 1*d*). The inner valley is a connected system of deep and now largely infilled gorges cut by the rivers into the bedrock during periods of Pleistocene lowstand of the sea. Most notable of these is the buried gorge of the Severn itself (Anderson, 1968), the rim of which (The Shoots) can be inspected intertidally along the north-western margin of English Stones in Avon. Similar features are known to be associated with other rivers in the area and some buried valleys are known where there is no river today (Codrington, 1898; Hawkins, 1962; Anderson & Blundell, 1965; Williams, 1968; Anderson, 1974; Gilbertson & Hawkins, 1978; Whittaker & Green, 1983). The outer valley possesses a gentle but complicated topography, accounting for the intricate form of the outcrop of the estuarine alluvium (Figure 1*b*), in which many unburied 'islands' and 'peninsulas' of bedrock persist in the modern landscape.

The evolution of the outer valley is poorly understood, but it is clear that fluvial, marine and periglacial processes have at different times been involved. Fluvial terrace gravels of various later Pleistocene dates (Wills, 1938; Hey, 1958, 1991) in places overlie the bedrock or occur in close association with the post-glacial estuarine alluvium (Figure 1*d*). What are considered to be beach gravels locally underlie the alluvium on the Welsh side of the outer Estuary (Andrews *et al.*, 1984). Ice-wedge casts and involutions of periglacial origin affect the soft Triassic and Jurassic bedrock, solifluction deposits, and the lower lying fluvial terrace gravels exposed in the lower, middle and inner Estuary (Gilbertson & Hawkins, 1978, 1983; Allen, 1987*a*). Blockfields emerge from beneath the alluvium where the bedrock is stronger. In Avon the ice-wedge casts (Plate 1) are well displayed at Hills Flats and Oldbury Flats, where a gently undulating bedrock surface emerges into the modern intertidal zone.

THE WENTLOOGE FORMATION

The main body of post-glacial estuarine alluvium in the Severn Estuary is assigned to a lithostratigraphic unit called the Wentlooge Formation (Allen, 1987*b*; Allen & Rae, 1987), named after the Wentlooge Level on the Gwent coast. A voluminous local literature (reviewed by Allen, 1990*a*), together with the evidence of a substantial number of largely unpublished commercial boreholes and the extensive intertidal exposures, makes it clear that the Wentlooge Formation, chiefly of mudflat-marsh origin, possesses a remarkably uniform general character throughout the area (Figure 1*d*). The main local variations lie in the nature and completeness of the lower strata, in response to the presence of undulations on the bedrock surface, and in the completeness of the uppermost beds, in the face of nearly two millenia of wetland reclamation. At the buried river gorges, however, a wide variety of specialized, local sequences are developed.

Lithologically, the Wentlooge Formation may be divided informally into three (Figure 1*d*). The lower Wentlooge Formation begins variously with thin gravels, sands, organic-rich sandy to gravelly paleosols and rooted, so-called basal peats. These grade up into silty sands and then thick bluish grey to greenish grey sandy to clayey silts. The character of these beds is well illustrated from the Avon area by the descriptions of Seddon (1964), Hawkins (1968), Jefferies *et al.* (1968) and Murray & Hawkins (1976). The middle portion of the Wentlooge Formation ranges from somewhat below OD to several metres above, and consists of an alternation of organic beds with greenish grey sandy to clayey silts. The organic beds vary from rooted peats, the thicker of which are seldom missed by drillers, to silts with dense rootlets and only a modestly elevated organic content. In age they range between about 6,500 and 2,500 conventional radiocarbon years (e.g. Heyworth & Kidson, 1982). A wide variety of wetland habitats apparently is represented, such as moist woodland, carr, reedswamp and raised bog (e.g. Coles & Coles, 1986; Smith & Morgan, 1989), across which various mammals roamed (e.g. red deer, wild horse, aurochs), to judge from finds of bones and teeth and the trackways preserved in the peats and associated silts (Plate 2). Excellent exposures and examples of these features can be seen in Avon on the foreshore off Wick St. Lawrence and Kingston Seymour, and again at Oldbury Flats and Hills Flats. Young to just mature alder and oak are the tree species chiefly found in the woodland facies, with willow coming in near to drainage lines. The trees mainly lie prostrate in the peat with the attached rootball vertical (Plate 3), and point toward a comparatively narrow range of generally easterly directions. They appear to have been felled by strong westerly winds, which modelling experiments indicate was

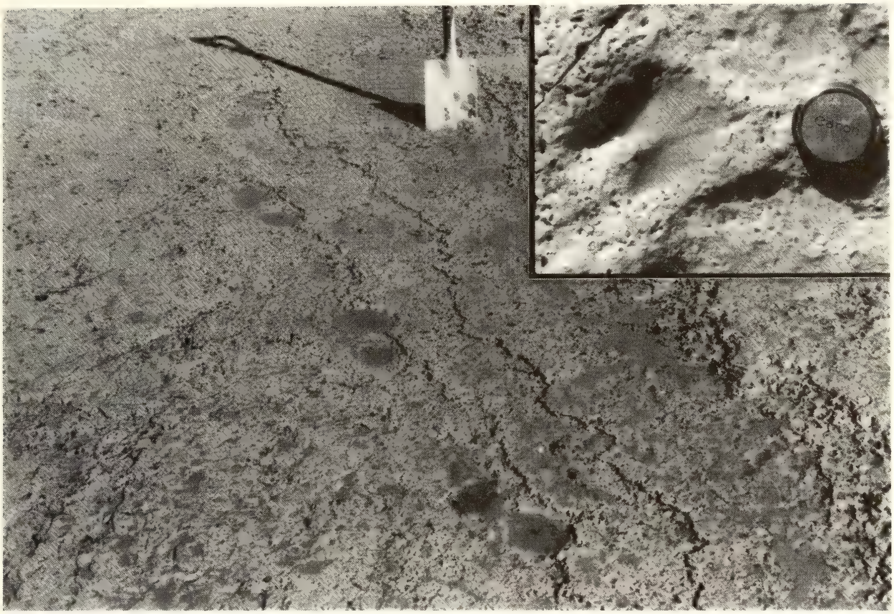

PLATE 2. Trackway formed of deep underprints (inset shows details of a track of a two-toed animal (?deer, aurochs) at a higher relative level), Wentlooge Formation, Oldbury Flats, Avon.

the prevailing direction (COHMAP members, 1988), rather than oriented by the tidal streams. The upper portion of the Wentlooge Formation consists of thick, greenish grey, sandy to clayey silts which grade up into green- brown mottled silts. These beds can be seen in freshly cleaned drainage ditches throughout the Avon reclamations and also on the shore at the mouth of Oldbury Pill and at Oldbury Flats. To judge from the prevalence of included trackways, now including those of large-footed cattle, the deposits record the occurence of a range of high tidal mudflats and marshes. Reclamation and the need for coastal defences, however, have permitted the Wentlooge Formation to go on accumulating up to the present day in just a very few places: for example, the highest of the active marshes between Aust Cliff and Oldbury Pill.

THE PREHISTORIC RECORD

The character of the post-glacial sequence in the Severn Estuary and inner Bristol Channel, and of the wetlands as we see them today, has been shaped by a lengthy interplay between human and natural forces. Whereas the evidence of prehistoric societies recorded from the main Somerset Levels (Coles & Coles, 1986) is of the first importance and justly famous, it has with little doubt distracted investigators away from the potential and significance of the wetlands as a whole.

There is increasing evidence that the wetlands generally present a rich resource of prehistoric archaeology, and one within the context of a sedimentologically

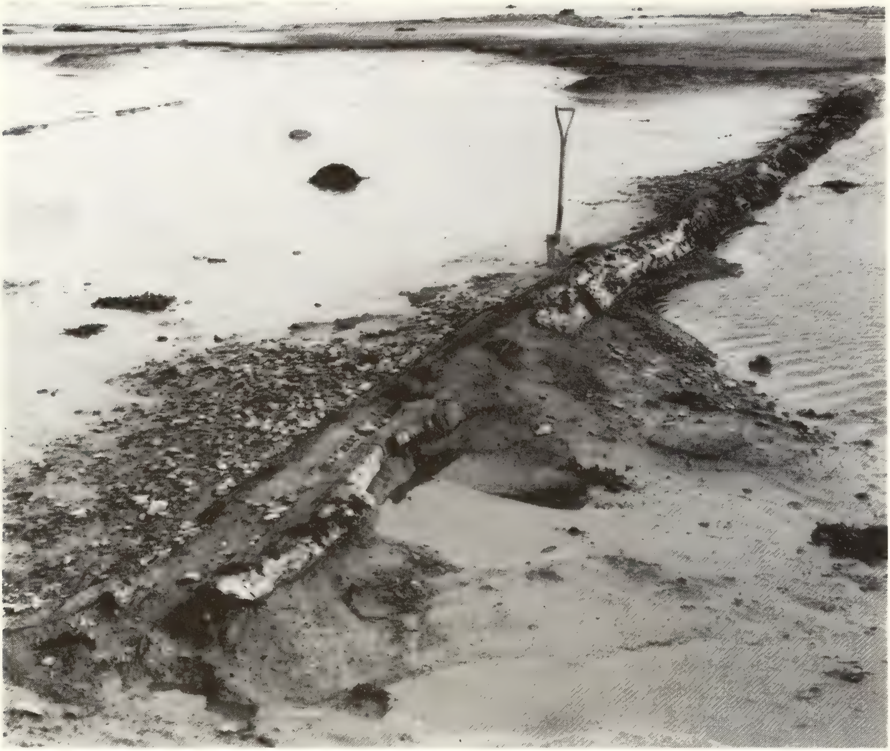

PLATE 3. Prostrate oak (22 m long) eroded from peat, Wentlooge Formation, Hills Flats, Avon. Rootball nearest camera. Spade for scale.

dynamic environment (Figure 2). Bronze Age occupation sites, together with other finds of that period and of the Neolithic and Iron Age, have been made in recent years at many places on the Gwent coast (e.g. Green, 1989; Whittle *et al.*, 1989). At Gold Cliff in this area, in association with a basal peat and an organic-rich paleosol developed on head with involutions, there is evidence for a probably late Mesolithic tool-making site in the form of unused raw materials, hammer stones, much lithic debris, and occasional implements. From the English bank of the Estuary come reports of Neolithic stone axes from intertidal and near-wetland contexts (Clough & Cummins, 1988; Allen 1990*b*), including the Portishead to Clevedon ridge, Oldbury Flats and Hills Flats. Another prehistoric tool-making site apparently existed at Oldbury Flats, where the peats of the middle Wentlooge Formation fuse and drape against a local rise in the bedrock surface. Blocks of various raw materials, perhaps traded in by boat, considerable amounts of debris, and a range of implements (blades, scrapers, scraper-knives, microliths) lie scattered about in the intertidal zone, but can in part be traced to the paleosol and basal peat. General hunting and reed-gathering over the older wetlands, however, is suggested by the well-used implements, e.g. leaf-shaped arrows are found from time to time here and at Hills Flats.

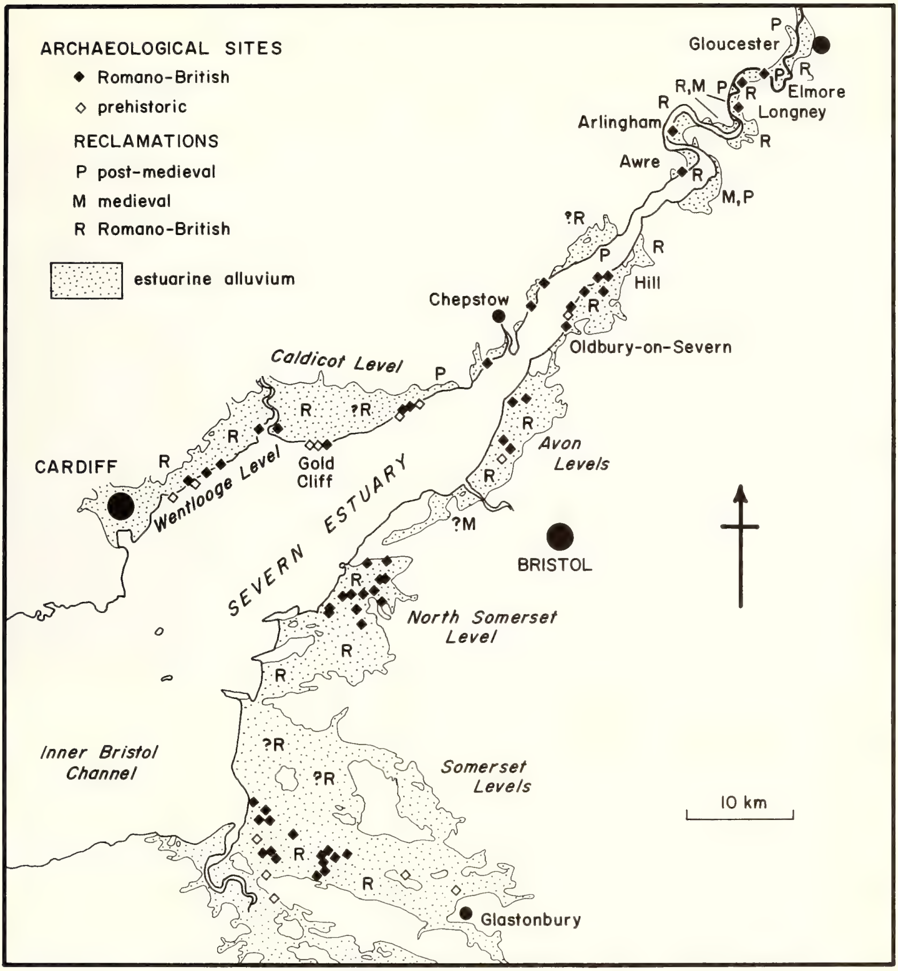
ARCHAEOLOGICAL SITES
◆ Romano-British
◇ prehistoric
RECLAMATIONS
P post-medieval
M medieval
R Romano-British
estuarine alluvium
Gloucester
Elmore
Longney
Arlingham
Awre
R,M
M,P
Hill
Chepstow
Oldbury-on-Severn
Caldicot Level
Wentlooge Level
Gold Cliff
CARDIFF
SEVERN ESTUARY
Avon Levels
?M
BRISTOL
North Somerset Level
Inner Bristol Channel
Somerset Levels
10 km
Glastonbury

FIGURE 2. Reclamations and chief wetland/intertidal archaeological sites in the inner Bristol Channel and Severn Estuary. See text for sources.

ROMANO-BRITISH AND LATER RECLAMATIONS

Human interference with the natural processes shaping the outcrop of estuarine alluvium began in earnest during the Roman period, with the reclamation behind artificial sea defences and drainage of great tracts of land throughout the area (Figure 2) (Allen, 1986, 1990*c*, *d*; Allen & Fulford, 1986, 1988, 1990, in press). The evidence for the earlier of these episodes of settlement takes the form of assemblages of building materials, pottery, animal bones and teeth, coins and items of personal adornment, and industrial raw materials and residues, which have been

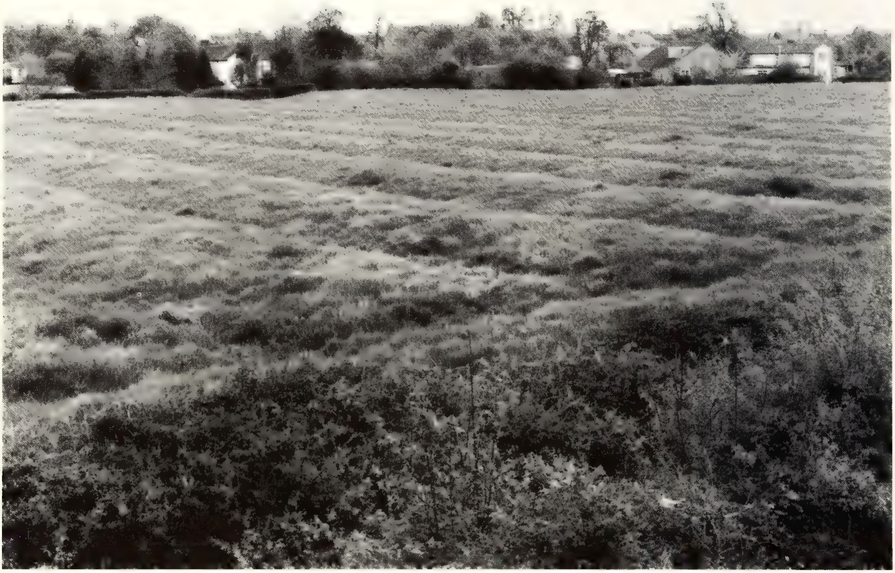

PLATE 4. Ridge-and-furrow in fields on reclaimed land, right bank of Oldbury Pill, Oldbury-on-Severn, Avon.

found either at sites scattered over the surviving outcrop of estuarine alluvium or in the contemporary intertidal zone at locations where the outcrop has been reduced because of post-reclamation shoreline erosion. The youngest reclamations, including some of medieval date, can in most cases be identified and dated using documentary evidence.

The Avon wetlands appear to have been reclaimed almost in their entirety by the end of the Roman period. The intertidal finds of pottery at Hill and Oldbury-on-Severn (Green & Solley, 1980; Copeland, 1981) are now known to be part of full occupation assemblages, to which can be added evidence for a number of inland occupation sites (Iles, 1984; Allen & Fulford, 1988; Allen, 1990*a*), activity having shifted from the Iron Age centre at Oldbury Camp overlooking the edge of the wetlands (Iles, 1980). The case for the reclamation of the Avon Levels, between Aust Cliff and the Bristol Avon, rests on a number of assemblages of occupation debris and indications of field systems (Everton & Everton, 1981). Lilly & Usher (1972) recorded many finds of Romano-British occupation debris from the North Somerset Levels, and it is here, on the banks of the Congresbury Yeo, that the substantial Wemberham villa is located (Scarth, 1886; Smyth-Pigott, 1886; Reade, 1886). The status of the main Somerset Levels in the Roman period is unclear. Much Romano-British activity occurred in the area (Cunliffe, 1966; McDonnell, 1985, 1986), but this could have been promoted more by the presence of natural sea defences (e.g. coastal dunes) than by artificial banks, which would only have been necessary along the rivers. The size and complexity of these Levels, however, makes it highly likely that interest in wetland reclamation and drainage varied greatly with time and local circumstances, as is certainly evident from the medieval period onward (Williams, 1970).

How the reclaimed lands were farmed during the Roman period remains unknown, but by medieval times practically all of the former marshland north-east of the Bristol Avon was under arable cultivation in great open fields. The proof of this (especially clear in air photographs) is the survival on the ground, among hedged fields largely pre-dating parliamentary enclosures, of generally well-preserved ridge-and-furrow (Plate 4) (see also Allen & Fulford, 1988; Allen, 1990*c*). This ancient field system (Hall, 1981, 1982; Astill, 1988) is characterized by the grouping into furlongs of narrow, sub-parallel strip fields called 'lands'. The lands are 5-10 m in width and can be up to 300 m long and as much as 0·75 m tall above the furrows. Typically, the strips have a reversed S-shape in plan, the result of long-repeated cultivation using a plough with a single mould-board, drawn anti-clockwise along the field.

POST-MEDIEVAL SHORELINE CHANGES

The narrow strips of wetland left unreclaimed in the Severn Estuary acted through post-medieval times as the sites of mudflat and marsh sedimentation, under the control of processes, some of which operated on a decadal to century time scale. Allen & Rae (1987) recognized that the active wetlands were underlain throughout the estuary by three erosively-based, offlapping morphostratigraphic units - the Rumney, Awre and Northwick Formations (Figure 3) - which descended stair-like toward the sea. Plate 5 illustrates these units as they outcrop at Northwick Warth on the Avon Levels. Their appearance on the ground (see also Hawkins, 1979; Smith, 1979) and erosional relationships are well illustrated at Oldbury Flats (Plate 6). These units of estuarine silt which underlie today's marshes began to form at a number of different times but, because each falls within the range of the tide, they simultaneously continue to receive sediment, albeit at a rate varying inversely with surface elevation relative to the tidal frame (Allen, 1991*b*).

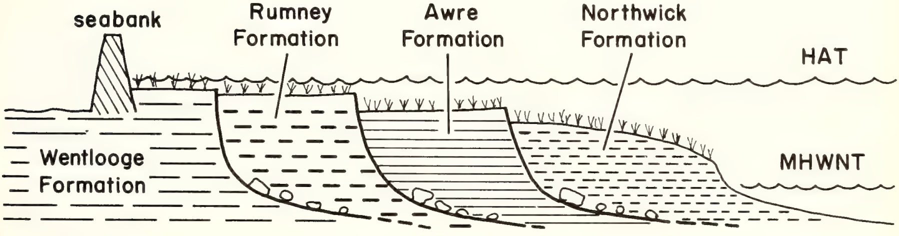

FIGURE 3. Schematic representation of morphostratigraphic units of the last few centuries associated with the contemporary, terraced salt marshes of the Severn Estuary.

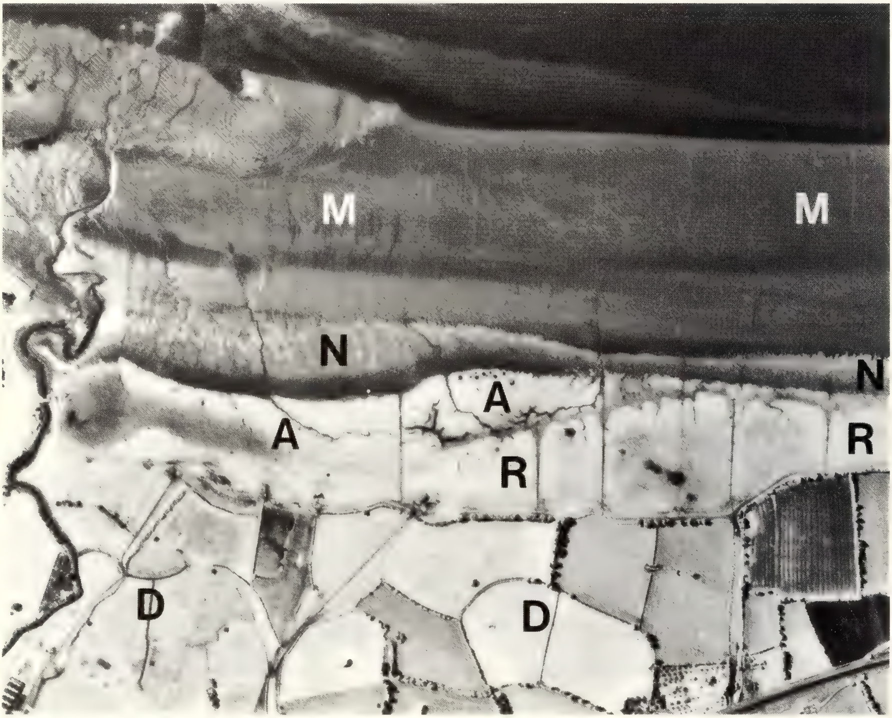

PLATE 5. Aerial view of reclaimed land (D), salt marsh and mudflats (M) at Northwick Warth, Avon. The marsh terraces are underlain by the Rumney (R), Awre (A) and Northwick (N) Formations. Area measures approximately 1,500 x 1,250 m. Crown copyright reserved.

Except at the very few surviving places where the accumulation of the Wentlooge Formation has continued to the present (e.g.. between Aust Cliff and Oldbury Pill), the highest marsh in the Severn Estuary is underlain by the Rumney Formation (Allen, 1987*b*; Allen & Rae, 1987), a sequence of thick pale brown silts grading up into much thinner mid and then dark grey silts. There is widespread ceramic evidence that these beds began to form no earlier than the late seventeenth or earliest eighteenth century (e.g. Allen & Fulford, 1986, 1988); they can be seen at several localities in Avon. The Rumney Formation is well exposed on the foreshore at Wick St. Lawrence where, with pottery at the base, it in places fills a complex of deep tidal channels cut into the middle and lower Wentlooge Formation. The beds also erosively succeed the Wentlooge Formation at Hills Flats and Oldbury Flats (Allen & Rae, 1987; Allen & Fulford, 1988), and at the entrance to Oldbury Pill sharply overlie the ploughsoil of an abandoned reclamation with ridge-and-furrow and a seabank (Allen, 1988). These relationships, combined with the presence of Romano-British pottery in the intertidal zone (e.g. Green & Solley, 1980; Copeland, 1981), suggest that, as on the Wentlooge Level (Allen & Fulford, 1986; Allen 1990*d*), an important medieval to early modern phase of erosion enforced a

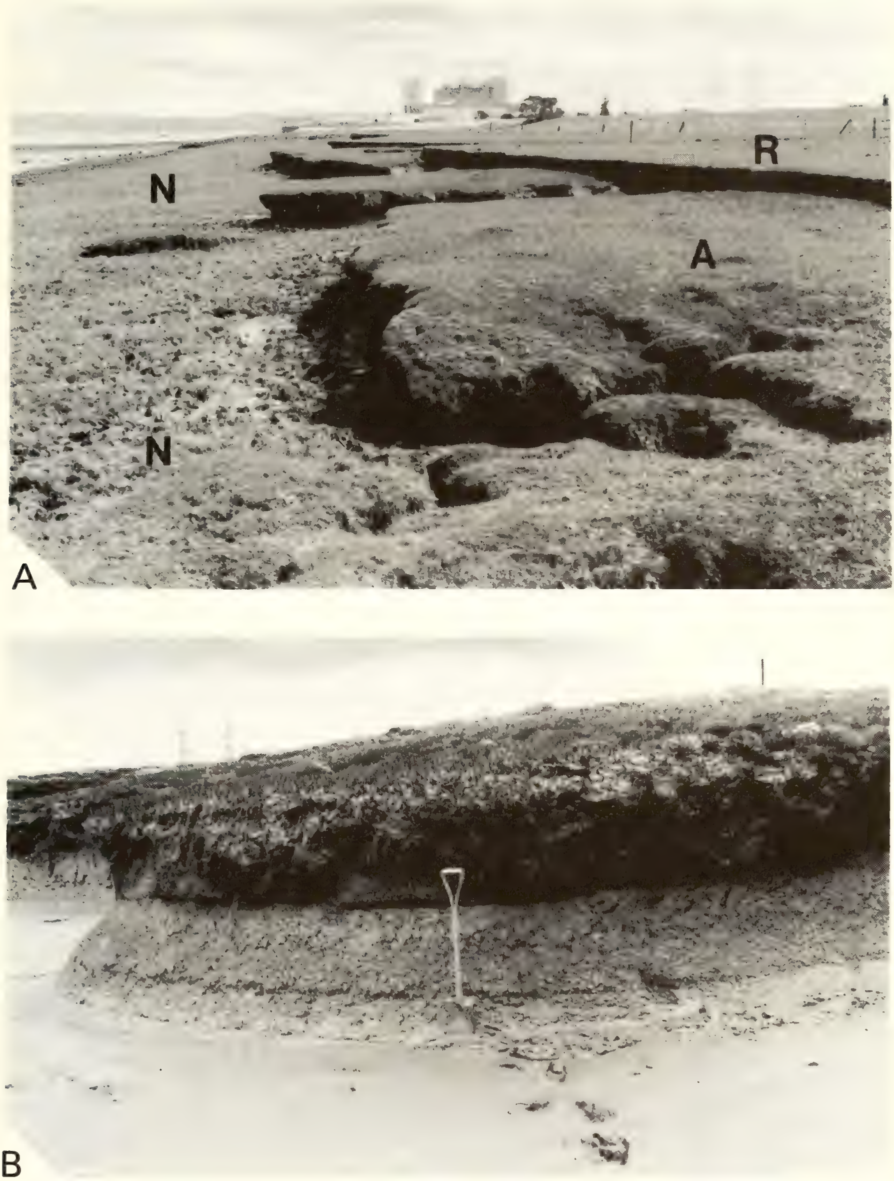

PLATE 6. *A*, marsh terraces underlying the Rumney (R), Awre (A) and Northwick (N) Formations, between Oldbury Pill and Oldbury Flats, Avon. *B*, discordant erosional contact (toward top of spade for scale) between the Northwick Formation and older deposits, Oldbury Flats, Avon.

widespread repositioning inland of the original Romano-British sea defences. The deposition of the Rumney Formation may therefore record the waning of the cool and apparently stormy conditions of the so-called Little Ice Age (Grove, 1988).

A second phase of shoreline erosion followed by mudflat-marsh accretion is recorded by the Awre Formation which underlies the middle marsh (Allen & Rae, 1987). This is a sequence of mid to dark grey silts, with brownish tones developing near the base which, on documentary and geochemical grounds, began to form in the late nineteenth century. Substantial anthropogenic pollution of the Estuary had already begun by the start of deposition, the reversal of pollutant trends which marks the boundary between Allen & Rae's (1986, 1987) Chemozones II and III, dating to about 1945, and occurring high up in the beds (see also Allen, 1987*c*, 1988). The Awre Formation in Avon is well exposed along Chittening and Northwick Warths, and can be seen also at Oldbury Flats. A lengthy outcrop at Hill, however, was destroyed during recent rebuilding of the sea defences.

The *Spartina*-dominated low marsh in the Severn Estuary (see Martin, 1992) is underlain by the Northwick Formation, a second sequence of chiefly dark grey silts which records the most recent episode of coastal erosion-accretion in the area. During the erosional phase, marsh cliffs at many places retreated inland at an annual rate of the order of 1m. Documentary, ceramic and geochemical evidence assigns the start of deposition of the Northwick Formation to the second quarter of the present century. The silts contributing to it are, for example, especially rich in heavy metals related to urbanization and industrialization, and in particulate pollutants such as coal dust, from mine washeries and coal-exporting ports, and fly-ash largely from the burning of pulverized coal for electricity generation (e.g. Allen & Rae, 1987; Allen, 1987*c*). The Northwick Formation is widely developed in Avon. It has an almost continuous outcrop from Hills Flats south-eastward to Aust Cliff, and from there along Northwick Warth and Chittening Warth. It reappears east and west of Portishead, off the North Somerset Levels, and at Stert Flats.

The presence of the Rumney, Awre and Northwick Formations in the area indicates that the high-tide shoreline of the Severn Estuary is very sensitive to regionally effective processes capable of varying in intensity on a decadal to century time scale. However, there is no evidence that relative sea-level has been changing in a stepped fashion (Woodworth, 1987, 1990) and, although marshes tend to become cliffed as they build higher relative to the tidal frame (Yapp *et al.*, 1917), the growth of relief provides no known mechanism for the replacement of erosion by accretion. It is difficult to accept that variations in the contribution of fine sediment by the rivers have controlled the regime, since the annual supply is small compared to the total amount of mud held at any one time in the estuarine water body (Collins, 1983). The most plausible interpretation of the offlapping sequence of morphostratigraphic units is that it records fluctuations in the regional wind-wave climate (Allen & Rae, 1987; Allen, 1987*b*). An increase in the severity of this climate should promote the direct quarrying of mud cliffs and platforms, together with the resuspension of any mud which had settled out at high tide. A decline may be expected to favour the incomplete resuspension of settled mud, leading to net accretion, the burial of erosion platforms and the consequent sheltering of mud cliffs. In support of this model is Lamb's (1982) finding that the annual frequency of days of westerly or south-westerly winds has declined substantially over the period represented by the Northwick Formation.

Mudflats and salt marshes, as absorbers of wave energy, contribute an important natural element to coastal defence, and it is of some practical concern, faced with the likely consequences of the added greenhouse effect, that in the Severn Estuary they should prove as shown above to be so impermanent. A related concern is the possible role that the mudflat-marsh deposits can play in determining the status of the system as a polluted environment. Large amounts of polluted sediment can become stored beneath mudflats and marshes during accretionary phases, only to be released later when the regime alters to an erosional one.

CONCLUSION

This paper was written in an attempt to begin to give coherence to existing knowledge of the Severn Estuary over the post-glacial period, an epoch of profound and interactive change in the natural order and in human society. Decisions concerning the use of the Estuary in the future can be sensible and sensitive only insofar as we understand the behaviour and history of this complex and challenging environment at present and over the recent past. Evidently, much remains to be done at a general level, as well as in detail. This paper is Reading University PRIS Contrib. No. 166.

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A HISTORY OF *SPARTINA* ON THE AVON COAST

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INTRODUCTION

One of the most spectacular, and one of the best documented, changes in vegetation cover in Britain caused by the invasion of a single species of plant has been the introduction into, establishment, and spread in and ultimately dominance of salt marshes by *Spartina anglica.*

The vigorous growth, extensive rhizomes and roots and the rather stiff leaves of *Spartina* make the plant an ideal agent for stabilizing unconsolidated estuarine muds and counteracting the erosion of muddy coastal shores. Thus the planting of *Spartina* (Cord-grass) into salt marshes as a form of coastal defence, reclamation and even use as grazing land was encouraged earlier this century by a publication from the Ministry of Agriculture and Fisheries (Oliver *et al.*, 1929). This publication reviewed methods of introduction and planting and described (including photographs) the striking success of the planting of *Spartina*, derived from Poole Harbour, in the polders of Holland. Furthermore this publication identified a commercial source of *Spartina* from Poole Harbour:

> "Mr Bob Cartridge, of Poole, a local fisherman, has for many years made a special study of *Spartina*, with the idea of supplying the requirements of correspondents. He has attended to these export requirements, and his long practical experience has taught him just which plants are best for the purpose and the necessary precautions in packing the consignments."

Ranwell (1967) gave further relevant details and photographs. Roper (1919*a*) reported, in 1917, on the growth of *Spartina* at Clevedon four years after its introduction there:

> "If the present rate of growth goes on with equal rapidity the mud will soon appear with thick vegetation on it ... and the hitherto soft mud will give sufficient support for a man to stand upon the ground without making more than a footmark".

Today the truth of this foresight is self–evident, for the species has now spread, by natural means and by intentional planting, throughout not only all the salt marshes of the Severn Estuary but also most of those elsewhere in England and Wales. Hubbard & Stebbings (1967) estimated that since *Spartina* x *townsendii* (sensu lato) was first collected in 1870 at Lymington the species had spread to cover some 29,742 acres (12,044 hectares) in Britain. Since their national survey, another by Charman (1990) concluded that "there seems to have been a marked overall increase in *Spartina* resources" despite showing great variation between increases and decreases at different sites.

Hubbard & Stebbings (1967) estimated the area of *Spartina* in the Severn Estuary to be: from Lilstock to the River Avon 566 acres (226·4 hectares) and from the River Avon northwards 323 acres (129 hectares). Smith (1979), in a specific survey of the Severn Estuary salt marshes, calculated the area occupied by *Spartina* as much greater: 488·3 hectares on the southern shore between Bridgwater Bay and Aust, 62·7 hectares north of the Severn road bridge (both shores), and a further 223·1 hectares on the north shore between Beachley and Cardiff.

Salt marshes are the dominant ecosystems of the coast of the Severn Estuary and the aim of this short account is to provide a guide to the spread of *Spartina* along the coast of Avon and adjoining counties. Much of the literature on this topic has been contributed by members of the Bristol Naturalists' Society and many of the details have been published in the Society's *Proceedings*.

ORIGIN AND TAXONOMY OF *SPARTINA*

Within the genus *Spartina* there are a number of species, two of which are native to Britain and others are present as aliens. The occurrence of a natural hybrid between *Spartina alterniflora* (a North American species) and *S. maritima* (a native species) was first described by H. & J. Groves in 1892 on material collected from Lymington in 1870. The plant was named *S.* × *townsendii* H. & J. Groves (also referred to in the early literature as *S.* × *townsendi*). This relatively vigorous hybrid seemed then to spread rapidly in Southampton Water and then spread or was planted elsewhere. All early (pre-1960s) accounts refer to the plants concerned as *S.* × *townsendii*. However, after evidence from chromosome counts and more critical examination of the plants, it was discovered that the very vigorously invasive plant, spreading by seed, was not referable to *S.* × *townsendii*. The new plant was called *S. anglica* by Hubbard (1968) and in 1978 he published a full diagnostic description. It appears that much of the planting of *Spartina* around our coasts has been with *S. anglica*, although some *S.* × *townsendii* also occurs. In the Severn Estuary a survey by Holland *et al.* 1986 (see also Holland, 1981, 1982) established that *S.* × *townsendii* is actually rather rare in the Severn, and that most of its stations are in the southern parts of the estuary. In the account below no distinction is made between the two taxa, although it is probably true that most British records refer to *S. anglica* rather than the sterile hybrid *S.* × *townsendii* sensu stricto, which can spread only by means of rhizomes.

HISTORY OF *SPARTINA* IN THE SEVERN ESTUARY

It is commonly assumed that Roper (1919*a*) was the first to report *S.* × *townsendii* in the Severn Estuary. However, the 30th Annual Report of the Watson Botanical Exchange Club for 1915 quotes a letter from H. S. Thompson (dated 15 November 1914) as follows:

> "I was much interested in hearing from the Rev. E. Ellman that *S. Townsendi* has been recently planted on the mud of the Bristol Channel, between Clevedon and Weston-super-Mare, to bind the mud and prevent it from being washed away. Some of the grass he saw actually being planted in rows a few weeks ago. Some had got more or less established, though planted only this year, I believe."

White (1918*a*) gave the date of 1913 for the start of the planting, the report being attributed to Ellman. The information given by Thompson (see above) was reiterated by Roper (1918, 1919*a*). The material used was stated to have come from Hayling Island and was split into about 1,000 tufts and planted in lines at Kingston Seymour (maps given by Roper, 1918, 1919*a*). This initial planting was later referred to, and the progress of its establishment and spread described by Roper (1918, 1919*a*, *b*, 1921, 1922). White (1918*b*) gave virtually the same facts, also referring to information from the Rev. E. Ellman, and described observations by Mr F. Samson and the local Wharf Warden. An interesting departure from the Roper accounts, however, is that the source of the *Spartina* is given as Poole. The Roper information as to the origin of the *Spartina* appears to have come from A. S. Davies (*in litt.*, undated letter to Miss I. M. Roper) who reported a conversation between 'a friend' and Mr Clothier, the landowner of the Kingston Seymour marshes. Furthermore, Davies reported to Miss Roper that Mr Clothier had been "induced" to plant the grass at Kingston Seymour after reading an article in *Country Life* (presumably Crump, 1912).

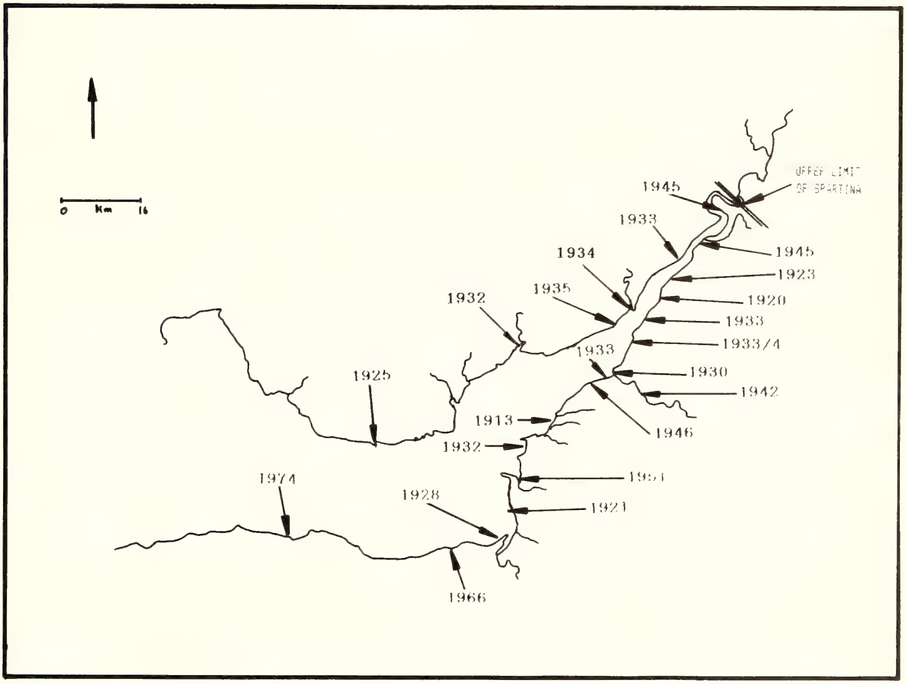

FIGURE 1. General map of the Severn Estuary showing positions and dates of first occurrence of *Spartina*. Authorities for records and sites are given in Table 1.

Table 1 lists the recorded dates of appearances of *Spartina* at particular places in the Estuary (see Figure 1). It should be stressed that the process of invasion was one of intentional planting, natural spread and eventually of infill planting.

Jefferies (1971) reported conversations with the foreman of the Severn River Board who had worked on the planting programme, noting that it was the board's policy to link up swards of *Spartina* by planting in areas of poor colonisation. An example quoted is at Severn Beach in 1965, which was the latest planting by that particular planting gang. At the present time *Spartina anglica* is virtually universal in all salt marshes extending up the Estuary to just beyond the Arlingham peninsula at Upper Dumball (Holland, 1982; Holland *et al.*, 1986).

Jefferies (1971), Carter (1974), Hubbard & Stebbings (1967) and Smith (1979) all used aerial photographs to help their studies of the invasion, rates of spread and status of *Spartina* in the Severn Estuary. Large (1967) showed how useful other photographic material may be in tracing the history of *Spartina*. He dated the introduction of *Spartina* at Aust as 1933 from a photograph of Aust Cliff in the first edition (1935) of *British Regional Geology - Bristol and Gloucester District*; the photograph clearly shows *Spartina* in the early stages of colonisation. Archive material of H. S. Thompson (Bristol University Library, Special Collections)

TABLE 1. List of dates and authorities for the first recorded occurrences of *Spartina* on the southern shores (south Avon and Somerset) and the upper and western shores of the Severn Estuary (north Avon, Gloucestershire, Gwent and South Glamorgan).

Date	*Site*	*Notes*	*Author*
Avon (south of River Avon) and Somerset			
1913	Kingston Seymour	Plantings derived from Hayling Island/Poole	E. J. T (1915) Roper (1918, 1919*a*) White (1918*a*, *b*)
1921	Gore Sands, Berrow	Plants washed up from Clevedon plantings	Thompson (1922) Thompson (1929) Boley (1943)
1928	Steart Flats	Plantings	Ranwell (1961)
1929	Bridgwater Bay	Plantings	Ranwell (1964*a*, *b*) Hubbard & Ranwell (1966)
1932	Sand Bay		Roe (1981)
1933	Portbury Wharf	Between Chapel Pill and Portishead	Whereat (1934)
1942	Banks of the Avon	Riverside below Portway opposite entrance to railway tunnel	Sandwith (1943)
1946	Portishead		Sandwith (1947)
1951	Uphill		Roe (1981)
1966	Lilstock	Natural spread	Hubbard & Stebbings (1967)
1974	Porlock Weir		Roe (1981)

Avon (north of River Avon), Gloucestershire, Gwent and South Glamorgan

1920	Oldbury	Plantings, stock from Holland	Jefferies (1971)
1923	Berkeley	Near Severn House Farm	Roper (1924)
1925	Barry		Goodman *et al.* (1959)
1930	Avonmouth	Beyond the docks	Sandwith (1943)
1932	Usk Estuary	Plantings	Hubbard & Stebbings (1967)
1933	Severn Bridge to Lydney		Whereat (1934)
1934	Beachley & Sedbury		Riddelsdell *et al.* (1948)
1933-4	Severn Beach	Plantings from Oldbury	Jefferies (1971)
1933	Aust	Photographic evidence	Large (1967)
1935	Portskewett		Wade (1980)
1945	Hock Cliff		Holland (1981)
1945	Sharpness Docks		Holland (1981)

contains photographs of the Berrow area in the late 1920s showing *Spartina* invasion (see Plate 1). The *Proceedings of the Bristol Naturalists' Society* for 1973 (Vol. 33, p. 72) shows outplantings of *Spartina* below Severn Beach in 1949 as further evidence of the value of photographic records.

Reports by Holland (1981) that two wagon loads of *Spartina* had been imported from the coast of East Anglia by a Squire Jenner-Fust of Hill and planted at Sheperdine "at the end of the last century" must raise some questions of accuracy of date and/or place of origin. The earliest record of *Spartina* in East Anglia appears to be 1907 (Hubbard & Stebbings, 1967; Goodman *et al.*, 1959) and Oliver *et al.* (1929) reported experiments set up by the East Anglian Institute of Agriculture on Essex salt marshes in 1925 with material from Poole Harbour. Furthermore, Jefferies (1971) reported that Mr Jenner-Fust planted *Spartina* from Holland at Oldbury *c.*1920; his information was a personal communication from a Mr J. Howse who worked on the plantings for the Severn River Board.

Areas of the Severn Estuary salt marshes which have received most ecological study since the introduction of *Spartina* have been Bridgwater Bay (Ranwell, 1961, 1964*a*, *b*, 1967; Morley, 1973; Hubbard & Ranwell, 1966), Berrow (Thompson, 1922, 1929, 1930; Boley, 1943; Hope-Simpson & Willis, 1955; Willis & Davies, 1960; Willis, 1992), Clevedon (Roper, 1918, 1919*a*, *b*, 1921, 1922), North Avon (Carter, 1974), Aust (Large, 1967) and Chittening Warth (Little, 1992). Extensive surveys of the Severn Estuary salt marshes were carried out by Smith (1979) and Teverson (1980). There is little doubt that the spread of *Spartina* has greatly extended the area of the marshes but has reduced dramatically the diversity of plant species and the numbers of birds present (Goss-Custard & Moser, 1990). Doody

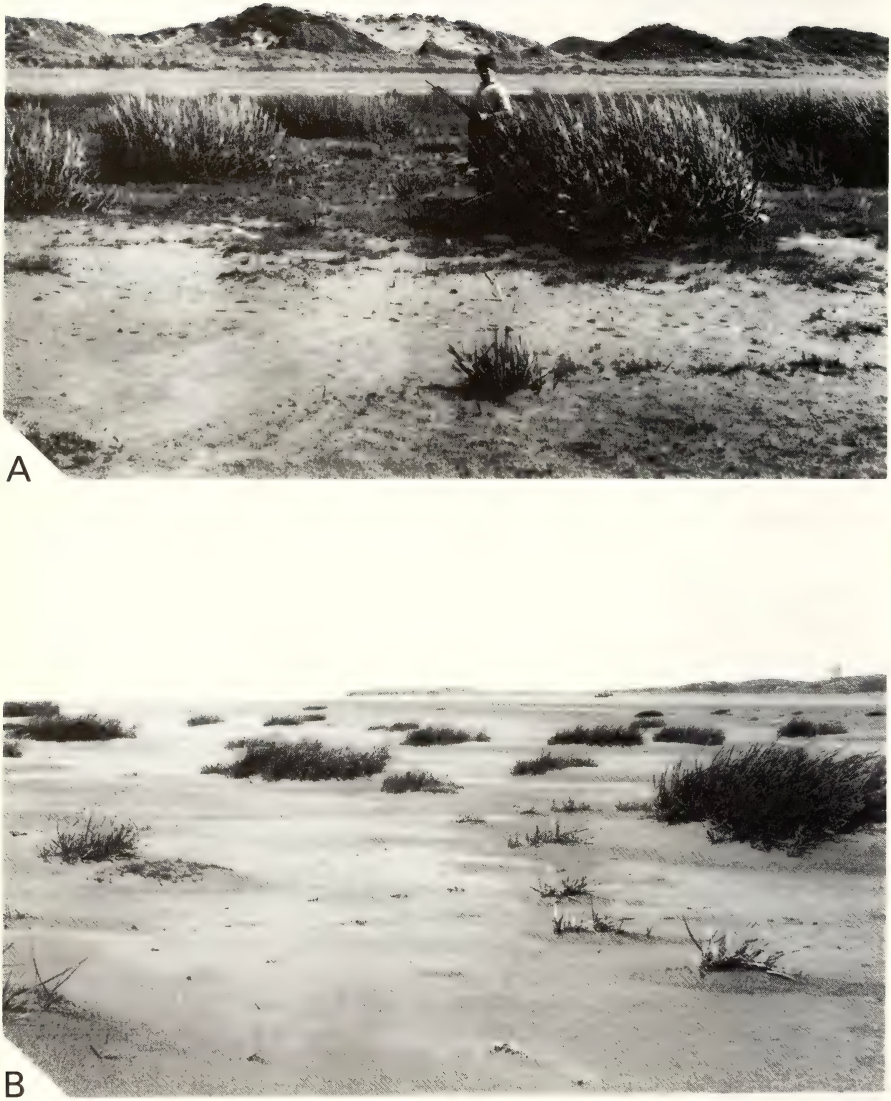

PLATE 1. A, Berrow Flats, snipe shooting amongst *Spartina* grass, August 1928 (Thompson, 1929, pl.). B, Berrow Flats showing the extent of *Spartina* invasion in August 1928; note the sand-dune ridge in the background and the tower of Berrow church as a landmark. Both photographs are reproduced from the H. S. Thompson Special Collection, University of Bristol.

(1990) concluded that the attributes which make *Spartina* such a good species for the stabilization of mud flats are also those which prevent it providing anything other than a reduced value for nature conservation. Certainly the emphasis has changed from active encouragement and planting of *Spartina* to processes of control and even in some places of eradication, all within a period of 70 - 80 years.

Plants which grow in virtual monoculture and which show rather limited variation (see Gray *et al.*, 1990 for variation in *Spartina*) are prone to extensive attack by disease and pest organisms. There is little evidence, however, that there has been any such widescale attack on *Spartina* swards. There are instances of decline of *Spartina* in some areas, but these appear to be linked to physical and chemical features of the sediment rather than attack by a specific organism (Goodman *et al.*, 1969). This decline has been called "die-back" and is associated with conditions of extreme anaerobiosis in the mud surrounding the root system of the affected *Spartina*. In Britain it is a local rather than a large-scale phenomenon.

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THE DEVELOPMENT AND VEGETATIONAL HISTORY OF BERROW SALT MARSH

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INTRODUCTION

At the beginning of this century the extensive expanse of mud and sand seaward of the dune system between Berrow and Burnham-on-Sea, North Somerset, bore no vegetation whatsoever. Since then, however, this area has been substantially colonized by plants and shown many changes. Drainage channels have originated and later silted up, with associated variations in sand and mud deposition; the vegetation has progressed from an initially fairly species-poor ecosystem to one of much diversity. There have been marked differences in dominance relations since the inception of the salt marsh; these vegetational as well as topographical changes have been well documented (Moss, 1907; Thompson, 1922, 1929, 1930; Kendall, 1939; Boley, 1943; Willis & Davies, 1960).

This paper traces the vegetational history of the marsh from its initial colonization resulting in the early dominance of *Puccinellia maritima* with much *Salicornia (*Latin and English names of plants mentioned in this paper, with some earlier synonyms, are given in an Appendix). It then progressed to a system dominated largely by *Spartina* and *Scirpus maritimus* in the 1930s and 1940s. By the 1960s the marsh had a very rich salt marsh flora, but the subsequent spread of *Phragmites australis*, which is now strongly dominant in much of the marsh, has led to a loss of diversity over a considerable area.

THE ORIGIN AND EARLY DEVELOPMENT OF THE MARSH

The flats seaward of the dunes at Berrow are very wide (some four miles (6·4 km) at low spring tides); the westerly winds carry a substantial supply of sand to the dune system. In his description of the area, Moss (1907) referred to the flats as lacking vegetation. He wrote (op. cit., p.8) 'Owing to the constant movements of the surface, caused by the ebb and flow of the tides, the flats possess no vegetation'. By 1921, however, an area of these flats, stretching north of the Low Lighthouse at Burnham-on-Sea and fringing the Berrow dune system, of some 100 acres (40 hectares), about 500 yds (460 m) wide and 1,500 yds (1,370 m) long, was vegetated to a considerable extent (Thompson, 1922). The date of the first colonization of the flats is not precisely known, but it seems likely that this was about 1910. However, there is little doubt that a major expansion of *Puccinellia maritima* and of *Salicornia* spp. occurred in the late 1910s and early 1920s. A map (Figure 1) of the marsh in 1921 (Thompson, 1922) shows the central part dominated by *Puccinellia*, with substantial amounts of *Salicornia* at the tapering southern extremity and also in parts of the northern end.

Sharply delimiting the marsh from the Gore Sand in 1921 was a newly developed channel, draining southwards to the River Parrett. This channel, nearly a mile

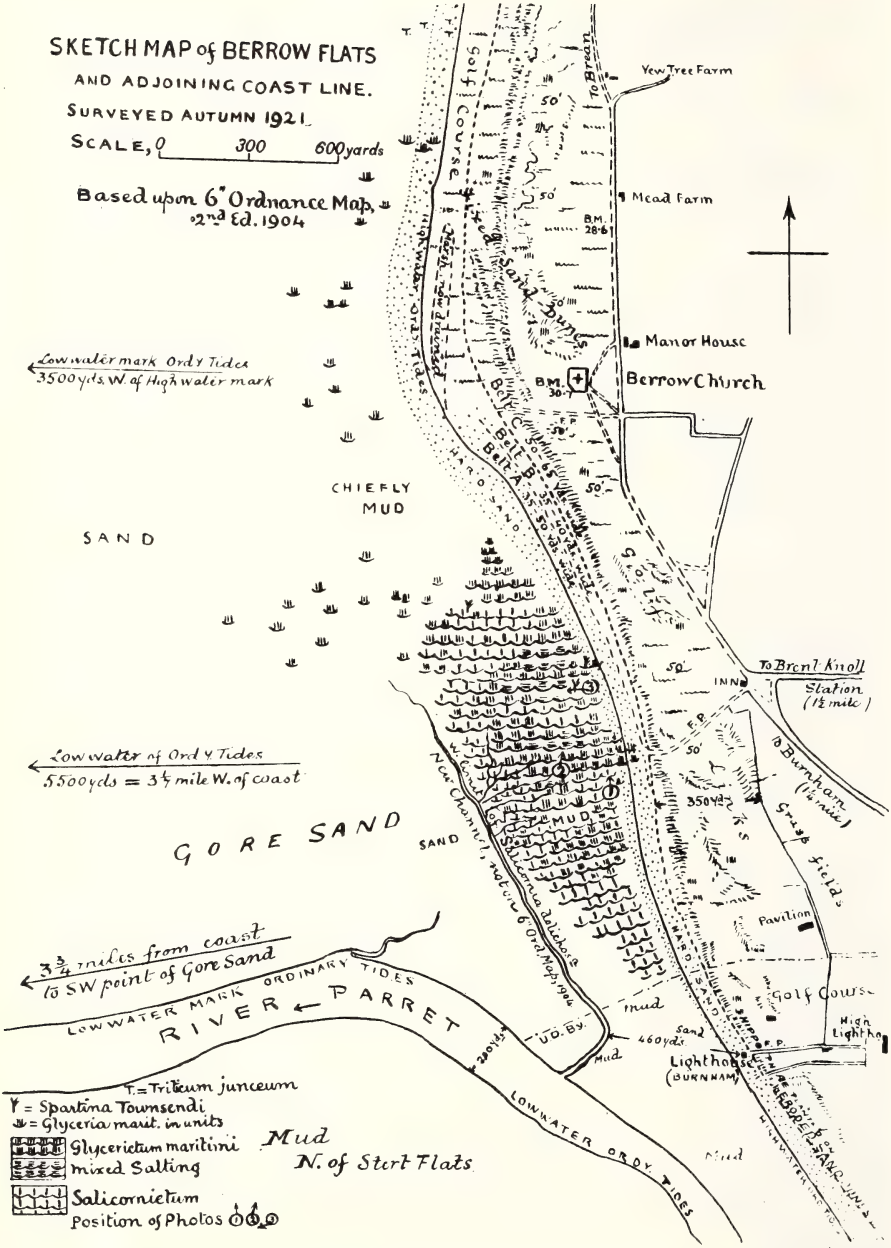
SKETCH MAP of BERROW FLATS
AND ADJOINING COAST LINE.
SURVEYED AUTUMN 1921
SCALE, 0 300 600 yards
Based upon 6" Ordnance Map, 2nd Ed. 1904
Yew Tree Farm
To Brean
Golf Course
Mead Farm
B.M. 28·6
Red Sand Dunes
Manor House
Berrow Church
B.M. 30·7
High water Ord. Tides
Low water mark Ord. Tides 3500 yds. W. of High water mark
CHIEFLY MUD
SAND
Belt C
Belt B
Belt A
HARD SAND
F.P.
50'
Golf Links
To Brent Knoll Station (1½ mile)
INN
To Burnham (1¼ mile)
Grass fields
Low water of Ord. Tides 5500 yds = 3¼ mile W. of coast
GORE SAND
SAND
MUD
New Channel, not on 6" Ord. Map, 1904
350 yds
Pavilion
Golf Course
High Lighthouse
3¾ miles from coast to SW point of Gore Sand
LOW WATER MARK ORDINARY TIDES
RIVER ← PARRET
280 yds
U.D. By.
mud
Sand 460 yds
Mud
Lighthouse (BURNHAM)
LOW WATER ORDY. TIDES
HIGH WATER ORD. TIDES
Mud
Mud N. of Stert Flats
T. = Triticum junceum
Y = Spartina Townsendi
= Glyceria marit. in units
Glycerictum maritimi
mixed Salting
Salicornietum
Position of Photos ①②③

FIGURE 1. The topography and vegetation of the Berrow salt marsh in 1921. From Thompson (1922, p.59). Reproduced with permission of The British Ecological Society.

(1·6 km) long and some 10 ft (3·0 m) deep and 40 ft (12·2 m) wide where it joined the Parrett about 600 yds (550 m) west of the Lighthouse, formed the western boundary of the '*Glyceria-Salicornia* association'. In 1911 no *P. maritima* was known on the Berrow Flats, but by 1921 this grass thickly covered a stretch of about 1,000 yds (915 m), being more sparsely scattered to the south and north of this area. However, it did not extend as near to the new channel as *S. dolichostachya* (a glasswort not previously recorded in the Bristol Channel) and *S. ramosissima*. The latter and *S. europaea* were subdominant on the marsh, but in places *Puccinellia maritima* was so thick that there was no other vegetation (see Plate 1A).

Other early colonists were *Triglochin maritima*, forming conspicuous large tufts in places, and the rayed form of *Aster tripolium*, present in smaller quantity. Only two small plants of *Suaeda maritima* were seen, but there were three large clumps of '*Spartina Townsendii*'; this Cord-grass had been planted on the coast south of Clevedon in 1913, the Berrow population perhaps originating from here (see also Martin, 1992). Notable absentees at this time were *Limonium vulgare*, *Armeria maritima* and *Plantago maritima*, major species of the British 'General Salt Marsh Association' as described by Moss (1907). A little *Zostera marina* was, however, reported (Thompson, 1922).

Strand plants of the Berrow coast area early this century included *Salsola kali*, *Eryngium maritimum*, *Glaucium flavum*, *Polygonum oxyspermum* ssp. *raii*, *Cakile maritima* and *Honkenya peploides*, all of which appeared to have declined somewhat by 1921. On the other hand, *Beta vulgaris* ssp. *maritima*, not mentioned by Moss (1907) as a strand plant, was occasional in 1921 (Thompson, 1922). Just landward of the strand was a belt (A, Figure 1) of *Elymus farctus*, followed inland by a zone (B, Figure 1) of slightly higher sand dominated by *Carex arenaria* and *Ammophila arenaria*. Still further inland was a higher belt (C, Figure 1), extending to the sand hills proper, with dominant *Ammophila arenaria*, abundant *Carex arenaria*, *Euphorbia paralias*, *Festuca rubra* and *Vulpia fasciculata*. Planted Sea-Buckthorn (*Hippophaë rhamnoides*) formed a generally low scrub, but sometimes reached 15 ft (4·6 m) high landward of this belt.

CHANGES IN THE COAST VEGETATION IN THE 1920S

By 1923 the deep mile-long channel forming the seaward limit of the marsh had become much silted up and the Salicornietum of 1921 had almost disappeared (Thompson, 1930). Although the marsh had extended at the northern extremity by about 100 yds (90 m), the south had lost some 300 yds (275 m). Major increases were evident in *Spartina anglica* (referred to by Thompson as *S. townsendi*), spreading largely no doubt by seed in the irregular seaward area of the marsh, and in *Aster tripolium*, which in many places formed a thick belt to landward, replacing *Puccinellia maritima* beneath it. *Scirpus maritimus* was first seen in 1926, and subsequently formed a dense broad belt on the landward wet muddy border of the marsh. By 1928 a zonation of *Scirpus*, *Aster* and *Spartina* from landwards to seawards was evident in some parts. At about this time the vegetation extended for about 1,100 yds (1,005 m) along the shore, was narrowed to no more than 300 yds (275 m), and was separated from the sand dunes by a strip of firm, mostly bare, sand. Drainage channels were present in the marsh (see Plate 1B) but did not appear to be frequent.

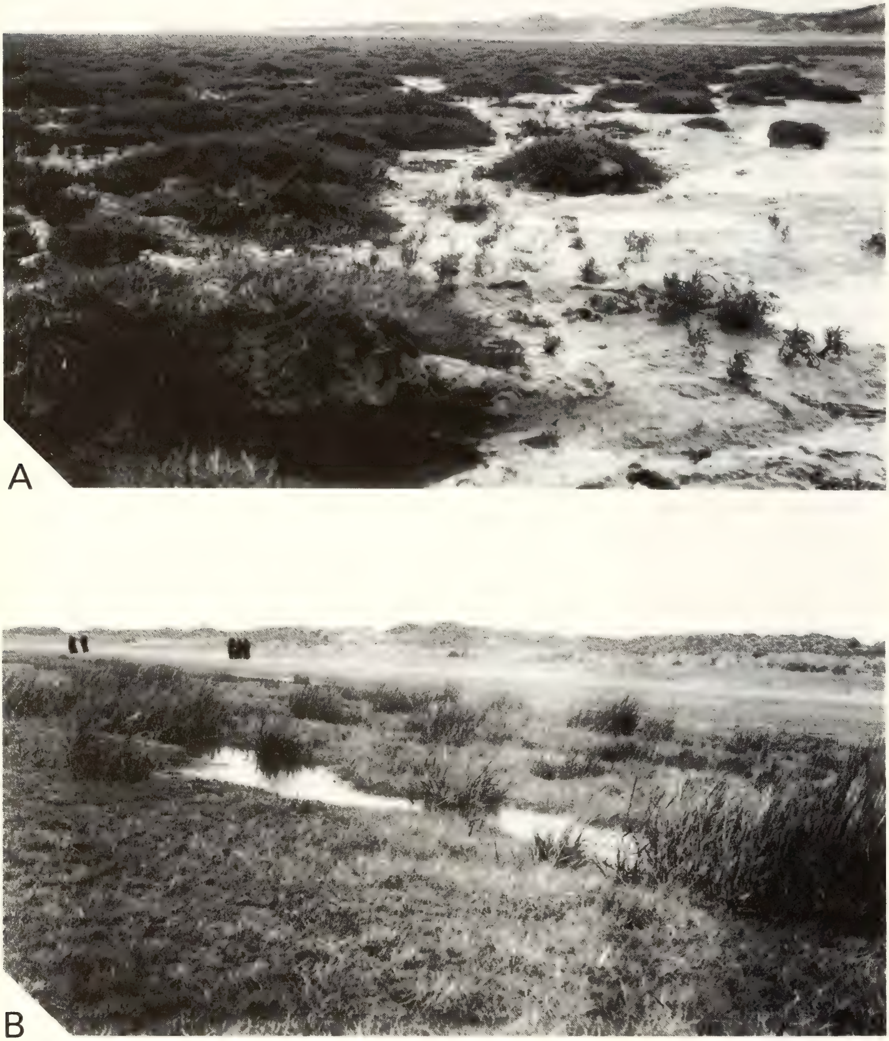

PLATE 1. A, view northwards of the salt marsh, flanking the dunes, autumn 1921. On wet mud in the foreground are scattered plants of *Salicornia*, mainly *S. dolichostachya*. The hummocks, 30-45 cm high, in the middle distance, are stabilized by *Puccinellia maritima*, which dominates a more closed vegetation further north. B, clumps of *Spartina*, mainly fringing a drainage channel, in the northern narrow part of the marsh, south-west of Berrow Church (tower visible on the horizon), with abundant *Puccinellia maritima*, 30 August 1928. Sisters of Mercy are walking on the strip of almost bare sand at the foot of the dunes. Photographs by H.S. Thompson, courtesy of the University of Bristol Special Collection.

By the late 1920s a number of plants typical of fresh-water conditions were present in the wettest part of the marsh nearest the former coast. These included *Alisma plantago-aquatica*, *Juncus articulatus*, *J. gerardi*, *J. inflexus*, *Triglochin palustris*, *Typha latifolia* (first noted in 1926), *Agrostis stolonifera*, *Carex otrubae* and *Schoenoplectus lacustris* ssp. *tabernaemontani*. Near the inland margin of the marsh *Glaux maritima* and *Spergularia marginata* were present in small quantity by 1928, with *Suaeda maritima* remaining also very sparse. In 1929 a few small plants of *Spergularia marina* were on mud near to the inland margin of the marsh. Plants in the vicinity of the strand included *Myosotis laxa* ssp. *caespitosa*, *Plantago coronopus*, *Ranunculus sceleratus* and *Rorippa palustris*. The major significant features at the close of the 1920s were the extensive spread of *Spartina* (see Martin, 1992, pl. 1) and the development of an Asteretum and Scirpetum, with non-halophytes appearing to landward. An unpublished manuscript dated 1935 by H.S. Thompson indicates the influx of some further colonists. In 1930 three clumps of *Carex extensa*, rare in Somerset, were seen on the margin of the new vegetation of Gore Flats, spreading considerably in subsequent years. In 1934 a large clump of *Juncus maritimus* was near the inland margin of the marsh. Also close to the inland margin were *Festuca arundinacea*, *Oenanthe lachenalii* and *Scutellaria galericulata*. Whereas in 1931 the most southern clumps of *Spartina* were about 480 yds (440 m) north of the Burnham Low Lighthouse, by 1933 small isolated clumps extended 90 yds (82 m) south of it.

THE MARSH IN 1938

In 1938 the marsh was about 1,250 yds (1,145 m) by 240 yds (220 m), with an area of approximately 44 acres (17·8 ha), there being evidence of overwhelmed vegetation in the north (Kendall, 1939). The large drainage channel present in 1921 as a tributary to the Parrett had completely disappeared by 1937, but a major gully was evident about half a mile (0·8 km) out to sea, which joined the Parrett. Creeks up to 2 ft (0·6 m) deep drained the marsh seaward with many 'winding streamlets', but some were transitory and others cut off by higher sand seaward of the marsh. At this time *Spartina anglica* dominated most of the marsh, with *Scirpus maritimus* and *Typha latifolia* at the inland border and *Juncus ambiguus* (cf. *J. bufonius*) also prominent, forming a belt near the inner margin in the south (Kendall, 1939).

THE MARSH IN 1942

A survey in 1942 (Boley, 1943) showed the marsh (Figure 2) to have extended to 1,550 yds (1,415 m) with a width for the most part of some 200-250 yds (185-230 m). The pioneer '*Glyceria-Salicornia*' community was much restricted, being largely confined to the north-west border of the marsh, where *Puccinellia maritima* and *Salicornia* spp. (*europaea*, *ramosissima*) were locally abundant. In muddy depressions in this vicinity were also *Aster tripolium*, *Halimione portulacoides* and *Suaeda maritima*, with *Elymus farctus* on small sandy elevations. *Spartina* was noted as far south as the Low Lighthouse (although only a single colony), and formed a dense cover on much of the marsh; the *Aster* belt was lost. The strong colony of *Scirpus maritimus* was up to 80 yds (73 m) wide, extending along the marsh for 1,050 yds (960 m), but was invaded at the landward margin by colonies of *Phragmites australis*. Towards the inland margin of the marsh, some 'pasture

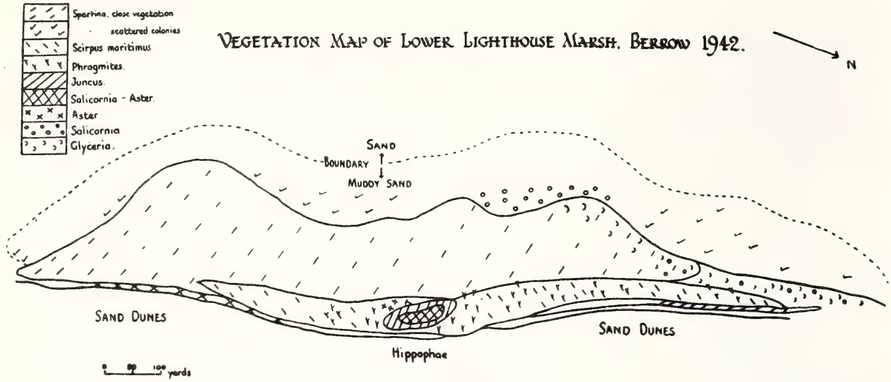
Spartina, close vegetation
scattered colonies
Scirpus maritimus
Phragmites
Juncus
Salicornia - Aster
Aster
Salicornia
Glyceria
VEGETATION MAP OF LOWER LIGHTHOUSE MARSH, BERROW 1942.
N
SAND
BOUNDARY
MUDDY SAND
SAND DUNES
Hippophae
SAND DUNES
0 50 100 yards

FIGURE 2. The vegetation of the marsh in 1942. From Boley (1943, p.428).

societies' were reported; species noted included *Festuca rubra*, *Trifolium fragiferum*, *Spergularia marginata* and *Glaux maritima*, with saplings of willow and seedlings of *Hippophaë rhamnoides*. Elsewhere on the marsh were *Apium graveolens* and *Parapholis strigosa*. Species usually of fresh water included *Apium nodiflorum*, *Iris pseudacorus* and *Lycopus europaeus*. In the open vegetation at the northern extremity where *Spartina* and *Puccinellia* were major components, *Glaux maritima* and *Juncus ambiguus* (cf. *J. bufonius*) were abundant, and also present were *Carex extensa* and *Juncus gerardi*.

THE MARSH IN THE 1960S

By 1963 the marsh (Figure 3) had spread further north, being about 1,700 yds (1,555 m) long, and had also increased in width, reaching a maximum of about 300 yds (275 m) in the central region. A number of drainage channels, some 4 ft (1·2 m) or more deep and up to about 10 ft (3·0 m) across, ended in small creeks within the marsh. After leaving the marsh the channels turned southwards, but petered out in the sand of the Berrow Flats before reaching the Parrett. At this time the marsh was frequently inundated by the tide, although in parts the seaward margin was flanked by newly formed dunes. These were quite well developed in the southern part of the system; also in the extreme north there was a line of dunes about 350 yds (320 m) long and up to some 8 ft (2·4 m) above the general level of the marsh. However, in the central region of the system the dune line was much dissected, with the sea entering this part freely and spreading considerably across the marsh.

The vegetation showed a distinct zonation (Figure 3) which correlated well with the conditions of salinity. Most seaward, and occupying nearly half of the marsh, was a dense stand of *Spartina*, the large majority of which was the fertile *S. anglica* (rapidly spread by seed). Very little of the sterile hybrid, *S.* × *townsendii sensu stricto* (vegetatively spread by rhizome) was present. Few species were able to grow in the zone dominated by *Spartina*, but *Atriplex prostrata* was occasional

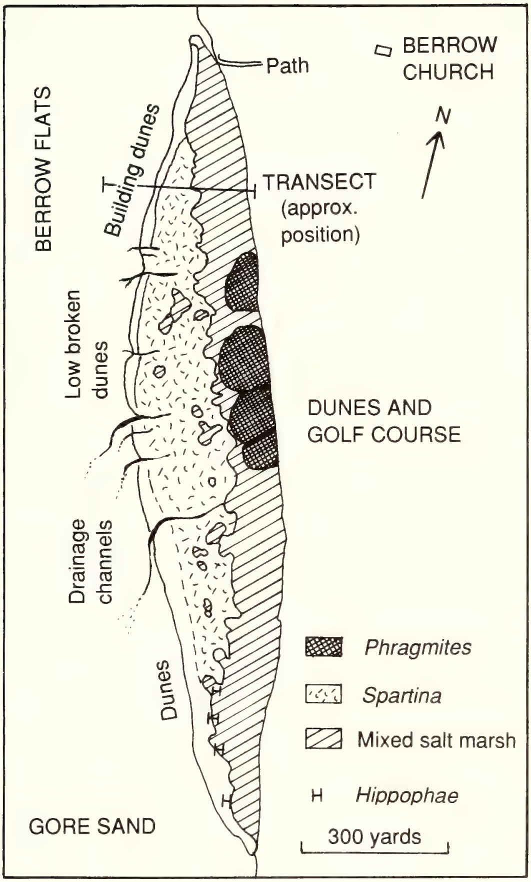
Path
BERROW CHURCH
N
BERROW FLATS
Building dunes
TRANSECT (approx. position)
Low broken dunes
DUNES AND GOLF COURSE
Drainage channels
Dunes
Phragmites
Spartina
Mixed salt marsh
H Hippophae
GORE SAND
300 yards

FIGURE 3. The marsh in 1963 showing the major features of the topography and vegetation. The map is based on aerial photography (courtesy of Meridian Airmaps) and on ground survey.

here. Along some of the creek banks was *Halimione portulacoides*; *Limonium binervosum* was present in the more open low areas by the large drainage channels.

Landward of the *Spartina* was a fairly narrow zone of *Scirpus maritimus* in some parts of the marsh, with few associates and forming a virtual monoculture in a number of places. However, this belt, where present, merged into the very diverse vegetation of the most landward part of the marsh. These zones are shown together in Figure 3, where they are referred to as 'mixed salt marsh'. The average salinity of the seaward margin of this 'mixed salt marsh' was about 1·0%, but the water in the most inland part was at times almost fresh. The water table here was subject to less change than that in other parts of the marsh, the inland margin being reached by only the highest tides and the water table being to an appreciable extent buffered by drainage of fresh water from the dune system.

Present near the northern end of the marsh in the *Scirpus maritimus* zone were two colonies of *Juncus subulatus*, the larger of which is shown in Figure 4. This maritime rush has its chief area of distribution in the Mediterranean; it was discovered at Berrow new to the British flora (Willis & Davies, 1960), and was unknown elsewhere in Britain until the 1980s. The two more or less circular colonies in the marsh were no doubt formed by radial spread of the extensive rhizome system. The date of its initial colonization was judged (based on growth rate and aerial photography) as being in the 1940s, the plant probably being brought in by shipping or by birds. As shown in Figure 4, a number of species besides *Scirpus maritimus* were important components of the vegetation of the 'mixed salt marsh' and dominated locally: notably *Carex extensa*, *Juncus gerardi* and *Festuca rubra*. Several other species were widespread, including *Apium graveolens*, *Aster tripolium*, *Glaux maritima*, *Oenanthe lachenalii*, *Plantago maritima* and *Triglochin maritima*. In some parts of the marsh *Berula erecta* was plentiful. The influence of nearly fresh-water conditions was no doubt reflected by the presence near the inland margin of the marsh of *Iris pseudacorus*, *Oenanthe crocata*, *Rumex hydrolapathum*, *Typha latifolia*, *Trifolium fragiferum* and *Agrostis*

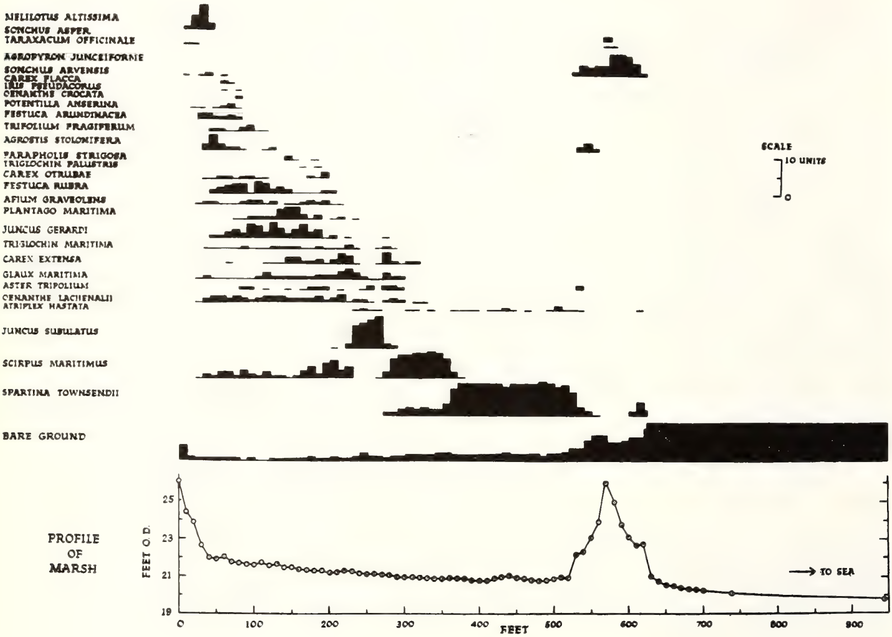

FIGURE 4. The profile and vegetation of a transect across the marsh, mid-August 1958. The position of the transect is shown in Figure 3. Contiguous areas 10 ft (3·0 m) long and 3 ft (0·9 m) wide along the transect were recorded. The vegetation was assessed (out of 10 units) by relative bulk of the component species, with an allowance for bare ground on an area basis. Adapted from Willis & Davies (1960, p.215). Reproduced with permission.

stolonifera. In the central section of the marsh several large colonies of *Phragmites australis*, originating at the extreme landward margin, were extending by clonal growth appreciably into the marsh. Their advancing edges were very sharply defined (Figure 4), and in a number of places *Phragmites* was overgrowing *Scirpus maritimus* and approaching the *Spartina* zone.

In the strand region of the old shore-line, frequent species included *Beta vulgaris* ssp. *maritima*, *Festuca arundinacea*, *Melilotus altissima* and, locally, *Thalictrum flavum*. The dunes delimiting the seaward north-western edge of the marsh were dominated by *Elymus farctus*; there was much bare sand, but dune plants were beginning to stabilize it. At the southern end of the marsh the dunes were generally higher and in some places protected by a thick scrub of *Hippophaë rhamnoides*.

THE MARSH IN 1990

Substantial changes in both the topography (affected by severe storms) and the vegetation of the marsh took place in the 1970s and 1980s. The low dunes at the northern extremity were partly eroded and replaced by small sand hillocks, mostly only 1-2 ft (0·3-0·6 m) above the general level, with this part of the marsh being highly exposed to tidal and storm action. The vegetation had nevertheless extended northwards (Figure 5), making the total length of the marsh a little over 1,800 yds (1,645 m). On the other hand, the width of the marsh, especially in the centre of the system, was appreciably diminished, the widest part in 1990 being about 250 yds (230 m) as compared with some 300 yds (275 m) in 1963.

An entirely new development was a substantial ridge of sand running obliquely across the marsh from the old shore-line to the bare sand of Berrow Flats, effectively dividing the marsh into two sections of unequal size. This dune line is now some 10-15 ft (3·0-4·6 m) above the level of the marsh, is closely vegetated on the north-west slope and also bears dense *Hippophaë* scrub, particularly along the crest and lee slope, giving the dune considerable stability. The marsh is now easily crossed on foot just north of this dune by a path which links the old shore-line to the Berrow Flats. The major part of the marsh south of the oblique dune is drained by only a single small channel. This strongly contrasts with the frequent drainage channels in the 1960s (Figure 3), some of which were large. The present channel, near the centre of the system, extends only a short distance into the marsh; it drains southwards towards Gore Sand but disappears shortly after leaving the marsh. A line of dunes is developing seaward of the marsh over virtually its whole southern stretch, but there are several low points where tidal incursion occurs. Much of this dune line, which in many places is more than 10 ft (3·0 m) above the general level, bears *Hippophaë rhamnoides* scrub which extends in a number of places some distance into the marsh. At the most southerly part of the marsh the seaward dunes are highest and more stabilized than elsewhere, isolating the marsh from the sea, except from tidal incursions further north.

The seaward dunes bear a closed vegetation in places but there is much bare sand and often very steep slopes on their eroding westward faces. The major stabilizing species in addition to *Hippophaë* are *Elymus farctus*, *Ammophila arenaria* and *Carex arenaria*. Other species present include *Prunus spinosa*, *Rubus fruticosus* agg., *Sambucus nigra*, *Cirsium arvense*, *Euphorbia paralias*, *Festuca rubra*, *Leontodon taraxacoides*, *Rumex crispus* and *Senecio jacobaea*. Less frequent are

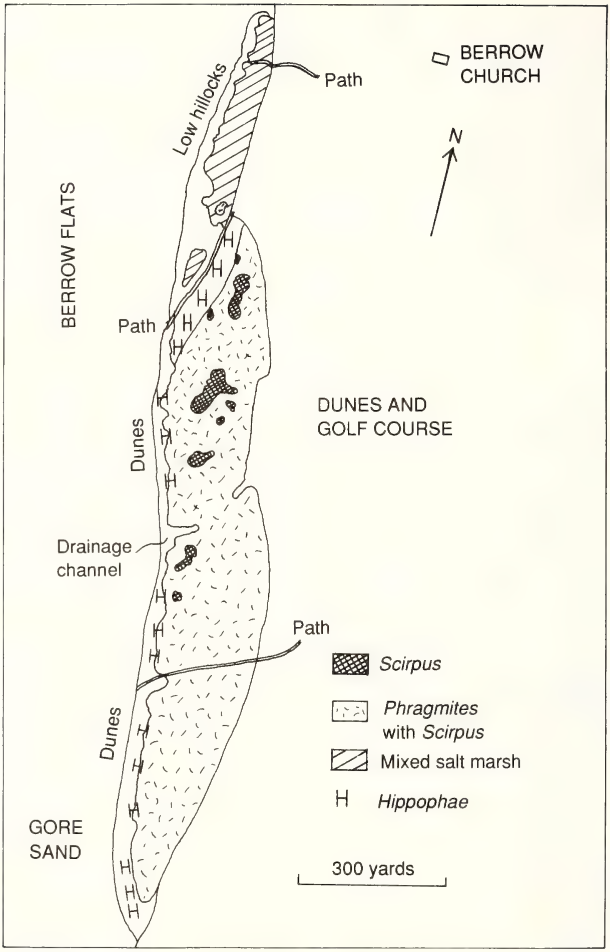
BERROW CHURCH
Path
Low hillocks
N
BERROW FLATS
Path
DUNES AND GOLF COURSE
Dunes
Drainage channel
Path
Scirpus
Phragmites with Scirpus
Mixed salt marsh
H Hippophae
Dunes
GORE SAND
300 yards

FIGURE 5. The topography and vegetation of the marsh in 1990, based on ground survey and aerial photography.

Anthriscus caucalis, *Cynoglossum officinale*, *Oenothera stricta*, *Phleum arenarium*, *Ranunculus bulbosus*, *Raphanus maritimus*, *Senecio vulgaris* and *Trifolium arvense*. At the seaward margin of the dunes are occasional plants of *Cakile maritima* and *Salsola kali*, and towards the foot of the seaward dunes on the marsh side *Phragmites australis* and *Elymus pycnanthus* form quite large patches in places. On the low dune hillocks at the north end of the system the chief stabilizer is *Elymus farctus*, and a little *Leymus arenarius* is also present.

In the larger southern section of the marsh *Phragmites australis* is overwhelmingly dominant over most of the area, being frequently up to 7-8 ft (2·1-2·4 m) tall, but often with an understorey of *Scirpus maritimus*. However, a number of almost pure, but relatively small, patches of *S. maritimus* are present in some of the wettest parts of the marsh, not yet invaded by *Phragmites*. There are only rather few associated species growing with the *Phragmites* and *Scirpus*, the most widespread being *Apium nodiflorum*, *Atriplex prostrata*, *Iris pseudacorus*, *Rumex hydrolapathum*, *Solanum dulcamara*, *Typha latifolia* and scattered *Salix cinerea* ssp. *oleifolia*. A large colony of *Juncus subulatus* (much south of the original site) is near to the inland margin of the marsh, growing with abundant *Phragmites australis* and *Scirpus maritimus* and frequent *Apium nodiflorum*, *Iris pseudacorus* and *Rumex hydrolapathum*. Less common here are *Carex otrubae*, *Mentha aquatica* and *Oenanthe lachenalii*; especially at the inland margin are *Carex acutiformis*, *Equisetum arvense*, *Hydrocotyle vulgaris*, *Juncus inflexus*, *Lycopus europaeus*, *Scutellaria galericulata* and *Solanum dulcamara*. Also in this vicinity is *Typha angustifolia*, thought but then disproved to be a colonist in the 1920s (Thompson, 1930), and a rare species in Somerset.

In the northern section of the marsh the vegetation is diverse. Although patches of *Phragmites australis* and of *Scirpus maritimus* are present, much of the vegetation is lower, with a wide range of species. The two original colonies of *Juncus subulatus* appear to have been buried by sand, but a new colonizer here is *J. acutus*, represented by a single but substantial tussock. *Juncus gerardi* is frequent and *J. maritimus* occasional, with some *J. inflexus* near the former shore-line. Dominating an appreciable area is *Carex extensa*, and *Elymus pycnanthus* is locally frequent. *Spartina anglica*, now absent from much of the south of the marsh, occurs in relatively small quantity in the northern section. Species which are widely distributed here include *Apium graveolens*, *Aster tripolium*, *Atriplex prostrata*, *Cochlearia anglica*, *Festuca rubra*, *Iris pseudacorus*, *Oenanthe lachenalii*, *Plantago maritima* and *Triglochin maritima* and *T. palustris*, these two species of Arrow grass sometimes growing very close together. On muddy sand at the margin of the salt marsh is *Juncus ambiguus* (recorded in quantity in 1986); this taxon was formerly included under *J. bufonius* and it seems highly probable that the references by Kendall (1939) and Boley (1943) to *J. bufonius* relate to *J. ambiguus* (a specimen of the latter was collected by the Sandwiths from Berrow in 1945). Rather less common are *Alisma plantago-aquatica* and *Centaurium pulchellum*, and on the somewhat drier ground are *Oenanthe crocata*, *Raphanus maritimus*, *Sonchus asper* and *Tripleurospermum maritimum*.

Along the edge of the old shore-line immediately inland from the marsh there is a fairly distinct band of vegetation, some 3-5 yds (2·7-4·6 m) wide. Major species here are *Festuca arundinacea*, *Melilotus altissima*, *Oenanthe crocata* and *Phragmites australis*. Other components of this usually tall vegetation include *Artemisia vulgaris*, *Calystegia sepium*, *Cirsium arvense*, *Convolvulus arvensis*, *Dactylis glomerata*, *Epilobium hirsutum*, *Equisetum arvense*, *Filipendula ulmaria*, *Ranunculus acris*, *R. bulbosus*, *R. repens* and *Urtica dioica*. Less common are *Cardaria draba*, *Lathyrus sylvestris*, *Lysimachia vulgaris* and *Tanacetum vulgare*. There is also occasional *Alnus glutinosa* and *Salix cinerea* ssp. *oleifolia*.

DISCUSSION

To an appreciable extent the changes in the vegetation in the Berrow salt marsh follow the general course of succession described for British salt marshes (Tansley, 1939; Chapman, 1960), but there are several distinctive features. The initial colonization by *Salicornia* and *Puccinellia* accords with the usual pattern, wit *Scirpus maritimus* becoming important at an early stage. The subsequent rapid spread of *Spartina anglica* is paralleled in other marshes of the Severn Estuary (Martin, 1992) and elsewhere in Britain (Goodman *et al*., 1969). The 'mixed marsh', represented to some extent by the 'pasture societies' in the 1940s (Boley, 1943), and well developed in the 1960s (Willis & Davies, 1960), typical of the higher levels of the ecosystem, contains many of the common plants of the varied vegetation of the 'general salt marsh'. However, *Limonium* spp. were never very abundant and *Armeria maritima* is virtually absent from the marsh (in 1962 a single tuft was recorded in an area of mud and sand at Berrow and in 1981 a small flowering clump at the seaward edge of the dunes). There seems no obvious reason for the lack of the Thrift (Sea Pink) at Berrow, this being fairly widespread in the Severn Estuary and Bristol Channel and it occurs on Brean Down; however, Thompson (1930) considered the marsh too wet for *Armeria maritima* in the 1920s.

The long continued spread of *Phragmites australis*, now strongly dominant over much of the marsh, which has outcompeted *Scirpus maritimus* and *Spartina anglica* as well as giving much reduced species diversity in the 'mixed marsh', appears to have been greater here than in salt marshes elsewhere in Britain. Landward invasion of *Spartina* marsh by *Phragmites* has occurred at Bridgwater Bay, Somerset (in one year advancing as much as 3 m; Ranwell, 1964), and also at Keysworth marsh, Poole Harbour, Dorset (Hubbard & Stebbings, 1968), but there were substantial areas of *Spartina* remaining to seaward in these marshes. The spread at Berrow has clearly been largely vegetative from the extensive rhizome system of colonies established on fairly dry parts of the former shore-line; however, in recent years it has spread landwards from colonies established, perhaps from seed, on the inland margins of the newly developed dunes seaward of the marsh. The extension has been progressively into the wetter and, at least originally, more saline parts of the marsh, its vigorous growth not being limited until 1·2% chlorinity of soil water (at 10-12 cm depth) is reached (Haslam, 1972). Indeed the plant can tolerate a salinity as high as 2·25% and some growth may be made even in sea water (Chapman, 1960). Dense growth of the common reed has led to some increase in the level of the marsh by the accretion of trapped mud and sand. Much debris brought in by a major storm early in 1990 was arrested by the *Phragmites* in the seaward parts of the marsh. The accretion gives drier and less saline conditions favouring *Phragmites* relative to *Spartina*, and the latter is also shaded out by the dense taller growth of the reed (Ranwell, 1964).

Particularly in the 1960s there was a clear zonation in the vegetation across the marsh, this pattern being related to the very gentle slope - a change of about 1 ft (0·3 m) over a distance of some 450 yds (410 m) - and consequently to the extent of tidal submersion and salinity. However, the topography now differs in some respects from that of many salt marshes. For example, in a number of places on the left bank of the Severn Estuary the salt marshes show a well defined zonation related to height above sea level, the gradient being very appreciable; indeed, in a number of places distinct 'steps' are present which may give as much as 6 ft (1·8 m) difference in level (Priestley, 1911). Such 'pelophilous formations' are, however, relatively narrow, and the system at Berrow is distinctive in having a very wide foreshore, with some parts of the Berrow Flats and Gore Sand having sand banks above the level of the marsh as well as ever-changing drainage channels. Another, no doubt related, distinctive feature at Berrow is the development of a line of dunes seaward of the marsh. These are now sufficiently high and stabilized over much of the southern section to make the isolation of this part of the marsh from the sea a distinct possibility. Tidal incursion is already much restricted here, conditions near the inland margin of the marsh being brackish (a measurement of salinity at the *Juncus subulatus* site in October 1990 gave a value of 0·6%). Should further dune development cut the marsh off from the sea entirely, this part of the salt marsh ecosystem would effectively become a slack or 'low' of the now extended dune system. Such an origin is typical of a prograding (advancing) shore-line (see e.g. Ranwell, 1972). Already a number of species commonly found in dune slacks are present in the marsh, e.g. *Hydrocotyle vulgaris*, *Agrostis stolonifera* and *Juncus gerardi*. The large marsh, three-quarters of a mile long and a quarter of a mile wide (*c*.1,200 m x 400 m), described by Moss (1907), landward of the foredunes seaward of Berrow Church, and many years ago extensively drained for the Golf Course and consequently vastly reduced, may have a similar origin (it once contained *Scirpus maritimus*, for example).

Many of the colonists of the marsh appear to have originated from other coastal sites in the Bristol Channel and Severn Estuary and some from the wet areas of the Berrow dune system. Long-distance transport must, however, have been involved with respect to *Juncus subulatus*, as its nearest known site to Berrow at the time of colonization was northern Spain. This rush has spread considerably by the growth of the rhizome system at Berrow but, as no 'daughter' colonies are at present known in the marsh, establishment in Britain from seed must be a very rare event.

SUMMARY

(1) About 1910 the foreshore between Burnham-on-Sea and Berrow first became vegetated; a salt marsh flora dominated by *Salicornia* spp. and *Puccinellia maritima* had developed over an area of about 40 hectares by 1921.

(2) Over the next twenty years, colonization by and extensive spread of *Scirpus maritimus* and *Spartina anglica* replaced most of the *Puccinellia-Salicornia* association. After some reduction in area of the marsh by 1938 there was an increase by 1942. A diverse flora developed on its inland margin.

(3) By the 1960s there was a zonation of vegetation correlated with salinity, the 'mixed salt marsh' forming the most inland belt becoming increasingly species-rich; *Juncus subulatus*, new to Britain, was discovered in the marsh.

(4) The spread of *Phragmites australis* into the marsh from the 1960s up to the present day has led to a great loss of *Spartina anglica* and to a lesser extent of *Scirpus maritimus*. Except for the northern part of the marsh, the diverse inland belt of vegetation has been overgrown by *Phragmites*. The marsh has effectively been divided into two by the formation of an oblique dune bearing much *Hippophaë*. A further strongly developing dune line to seaward in the southern section of the system is much restricting tidal incursion, suggestive of the possible progression of this part of the marsh to a dune slack.

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APPENDIX

Latin and English names of plants referred to in the text (some earlier synonyms are also given in parentheses).

Agrostis stolonifera (*A. alba*)	Fiorin, Creeping Bent
Alisma plantago-aquatica	Water-Plantain
Alnus glutinosa	Alder
Ammophila arenaria (*A. arundinacea*)	Marram Grass
Anthriscus caucalis (*A. neglecta*)	Bur Chervil
Apium graveolens	Wild Celery
Apium nodiflorum	Fool's Watercress
Armeria maritima	Thrift, Sea Pink
Artemisia vulgaris	Mugwort
Aster tripolium	Sea Aster
Atriplex prostrata (*A. hastata*)	Hastate Orache
Berula erecta	Narrow-leaved Water-Parsnip
Beta vulgaris ssp. *maritima* (*B. maritima*)	Sea Beet
Cakile maritima	Sea Rocket
Calystegia sepium	Hedge Bindweed, Belbine
Cardaria draba	Hoary Cress, Hoary Pepperwort
Carex acutiformis	Lesser Pond-sedge
Carex arenaria	Sand Sedge
Carex extensa	Long-bracted Sedge
Carex flacca	Glaucous Sedge, Carnation-grass
Carex otrubae (*C. vulpina*)	False Fox-sedge
Centaurium pulchellum	Lesser Centaury
Cirsium arvense	Creeping Thistle
Cochlearia anglica	Long-leaved Scurvy-grass
Convolvulus arvensis	Field Bindweed, Lesser Bindweed
Cynoglossum officinale	Hound's-tongue
Dactylis glomerata	Cock's-foot
Elymus farctus (*Agropyron junceiforme, A. junceum*)	Sand Couch-grass
Elymus pycnanthus (*Agropyron pungens*)	Sea Couch-grass
Epilobium hirsutum	Great Hairy Willow-herb
Equisetum arvense	Field Horsetail
Eryngium maritimum	Sea Holly
Euphorbia paralias	Sea Spurge
Festuca arundinacea	Tall Fescue
Festuca rubra	Red Fescue
Filipendula ulmaria	Meadowsweet
Glaucium flavum	Yellow Horned-poppy
Glaux maritima	Sea Milkwort
Halimione portulacoides (*Atriplex portulacoides*)	Sea Purslane
Hippophae rhamnoides	Sea-Buckthorn
Honkenya peploides (*Arenaria peploides*)	Sea Sandwort

Hydrocotyle vulgaris	Marsh Pennywort
Iris pseudacorus	Yellow Iris, Yellow Flag
Juncus acutus	Sharp Rush
Juncus ambiguus (cf. *J. bufonius*)	Toad Rush
Juncus articulatus	Jointed Rush
Juncus gerardi	Saltmarsh Rush
Juncus inflexus (*J. glaucus*)	Hard Rush
Juncus maritimus	Sea Rush
Juncus subulatus	Somerset Rush
Lathyrus sylvestris	Narrow-leaved Everlasting-pea
Leontodon taraxacoides	Hairy Hawkbit
Leymus arenarius (*Elymus arenarius*)	Lyme-grass
Limonium binervosum	Rock Sea Lavender
Limonium vulgare (*Statice limonium*)	Sea Lavender
Lycopus europaeus	Gipsywort
Lysimachia vulgaris	Yellow Loosestrife
Melilotus altissima	Tall Melilot
Mentha aquatica	Water Mint
Myosotis laxa ssp. caespitosa (*M. caespitosa*)	Tufted Forget-me-not
Oenanthe crocata	Hemlock Water-Dropwort
Oenanthe lachenalii	Parsley Water-Dropwort
Oenothera stricta (*O. odorata*)	Fragrant Evening Primrose
Parapholis strigosa (*Lepturus filiformis*)	Hard-grass
Phleum arenarium	Sand Cat's-tail
Phragmites australis (*P. communis*)	Common Reed
Plantago coronopus	Buck's-horn Plantain
Plantago maritima	Sea Plantain
Polygonum oxyspermum ssp. *raii* (*P. raii*)	Ray's Knotgrass
Potentilla anserina	Silverweed
Prunus spinosa	Blackthorn
Puccinellia maritima (*Glyceria maritima*)	Common Saltmarsh-grass
Ranunculus acris	Meadow Buttercup
Ranunculus bulbosus	Bulbous Buttercup
Ranunculus repens	Creeping Buttercup
Ranunculus sceleratus	Celery-leaved Crowfoot
Raphanus maritimus	Sea Radish
Rorippa palustris (*Nasturtium palustre*)	Common Marsh Yellow Cress
Rubus fruticosus agg.	Blackberry
Rumex crispus	Curled Dock
Rumex hydrolapathum	Water Dock
Salicornia dolichostachya	
Salicornia europaea (*S. herbacea*)	Glasswort
Salicornia ramosissima	Prostrate Glasswort
Salix cinerea ssp. *oleifolia* (*S. atrocinerea*)	Rusty Sallow
Salsola kali	Prickly Saltwort
Sambucus nigra	Elder
Schoenoplectus lacustris ssp. *tabernaemontani* (*Scirpus tabernaemontani*)	Bulrush
Scirpus maritimus	Sea Club-rush
Scutellaria galericulata	Skullcap
Senecio jacobaea	Ragwort

Senecio vulgaris	Groundsel
Solanum dulcamara	Woody Nightshade, Bittersweet
Sonchus arvensis	Field Milk-Thistle, Corn Sow-Thistle
Sonchus asper	Spiny Sow-Thistle
Spartina anglica	Common Cord-grass
Spartina × townsendii	Townsend's Cord-grass
Spergularia marginata	Greater Sea-spurrey
Spergularia marina (*S. salina*)	Lesser Sea-spurrey
Suaeda maritima	Annual Seablite
Tanacetum vulgare	Tansy
Taraxacum officinale agg.	Dandelion
Thalictrum flavum	Common Meadow Rue
Trifolium arvense	Hare's-foot Clover
Trifolium fragiferum	Strawberry Clover
Triglochin maritima	Sea Arrowgrass
Triglochin palustris	Marsh Arrowgrass
Tripleurospermum maritimum	Sea Mayweed
Typha angustifolia	Lesser Bulrush
Typha latifolia	Bulrush, Cat's-tail
Urtica dioica	Stinging Nettle
Vulpia fasciculata (*Festuca uniglumis*)	Dune Fescue
Zostera marina	Eelgrass

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THE MUDFLAT ECOSYSTEM AND EPIPELIC DIATOMS

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ABSTRACT

A variety of microorganisms inhabit the surface sediments of intertidal mudflats. Some are capable of using light energy from the sun to produce food by photosynthesis. A common example of such organisms are the epipelic diatoms. Diatoms are small unicellular plants which can grow attached to surfaces, floating in water or on the surface of sediments. Members of this last group are described as epipelic and are well adapted to life both on the surface and moving in and out of the sediment. Epipelic diatoms contribute significantly to the food web of an estuary because of their ability to photosynthesise, and are particularly important when photosynthesis by organisms living in the water is restricted by its turbidity or "muddiness", as in the Severn Estuary. The life form and ecology of epipelic diatoms is briefly introduced and the seasonal distribution and abundance of epipelic species at different heights on the surface of the mudflat at Aust is reported. At high-shore sites the species composition varies markedly with season, while low-shore communities show far less seasonal change. Reasons for this difference in response to environmental conditions are discussed.

INTRODUCTION

The fine sediments which accumulate to form mudflats along the coasts of estuaries appear to many as barren and uninviting habitats. However, mudflats can be extremely productive and act as important feeding grounds for young fish and migrant birds. These vertebrates feed on small animals such as snails (e.g. *Hydrobia ulvae)* and worms (e.g. *Nereis diversicolor)* which in turn depend upon other sources of nutrition. In estuaries, this nutrition is derived from three basic sources: 1, microbes living on the sediments which can use light energy to photosynthesise carbohydrates; 2, photosynthesis by small plants (phytoplankton) in overlying tidal waters; and 3, the influx of organic material and nutrients from other sources, such as the sea, river, land or salt marsh. According to Reise (1985) the three inputs are normally of approximately equal value, but this does depend on local conditions. In the Severn Estuary phytoplankton productivity is extremely low because large amounts of sediment suspended in the water prevent the penetration of enough light to support photosynthesis. Consequently, productivity by photosynthetic organisms on the surface of the mudflats is of greater relative importance.

Several groups of organisms exploit the difficult conditions within the shifting sediments of the intertidal mudflats below the salt marshes. Most photosynthetic forms are microbial, including protists, unicellular algae, blue-green algae (cyanobacteria) and other photosynthetic bacteria. A few larger forms, such as the green filamentous alga *Vaucheria* spp., also encroach on the flat from the edge of the salt marsh and often appear as small isolated patches of fine grass-like growth.

On the surface of the mudflat proper, the dominant photosynthetic organisms are protists and unicellular algae and, of these, the diatoms are often more abundant. This paper describes some of the problems of the intertidal sediment environment, introduces the diatoms (particularly the epipelon) and examines the ecological strategies that have made them so successful in exploiting conditions on the surface of intertidal mudflats. Many topics are only briefly introduced but some references are supplied to lead the reader to more detailed discussion.

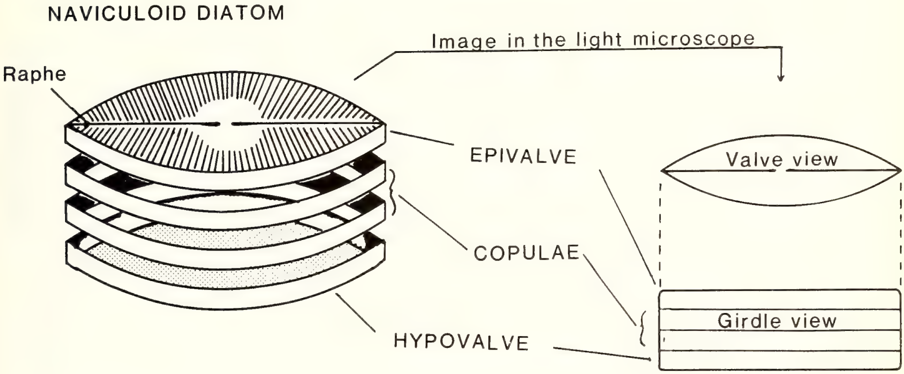

FIGURE 1. A very simplified schematic diagram of a pennate diatom cell outlining its construction, including the two valves (*epivalve* and *hypovalve*) and the *copulae*. When viewed on a microscope slide, a diatom is usually seen lying on one valve face (the *valve view*) or lying on its side (the *girdle view*), when the copulae are visible.

DIATOMS

Diatoms are single-celled algae which range in size from several μm (a thousandth of a millimetre) up to 0·5 mm in length. They are more correctly known as the Bacillariophyta, and are distinguished from other unicellular plants by having cell walls composed of a transparent rigid silica shell, almost like a glass case. This hard shell is in two halves (*valves*) joined together by bands of silica (*copulae*: Figure 1). The valves are termed the *epivalve* and *hypovalve* which relate to the process of cell regeneration (see Round *et al.*, 1990 for details of the complex structure and development of diatom cells). Diatoms can be roughly divided into round *centric* forms and more elongated *pennate* forms which show bilateral symmetry. Those which dominate the intertidal sediment largely belong to the latter category (Figure 1).

Many pennate diatoms can propel themselves through the sediment by exuding mucilage through slits in the valve faces (*raphes*, Figure 1). The diatoms which move on and within the surface sediments are collectively described as *epipelic* and the total assemblage of organisms is termed the *epipelon* (Round, 1981).

These microscopic algae can be revealed by light microscopy (Plate 1B) or by using a scanning electron microscope (SEM). The mud surface can be visualised very accurately by taking a small sample of mud on silver foil (Plate 1A) and freezing it in liquid nitrogen to preserve its structure and prevent further diatom locomotion. The sample is then examined by low-temperature SEM (LTSEM), at a temperature of -180°C within the microscope (Paterson *et al.*, 1986). Examples of LTSEM micrographs showing details of sediment surfaces colonised by epipelic diatoms are given in Plate 1C-F.

MUDFLATS AS HABITATS

SEDIMENTS

The distribution of sediments within a river system depends largely on the speed of flow. High energy flow can transport large particles but as the river widens or deepens and slows these settle out, leaving only smaller particles in suspension. This effect leads to a "sorting" of particles, and usually only the smallest are still being carried when the system widens into an estuary. The widening is accompanied by further slowing, and by the mixing of fresh and salt water which causes flocculation and the settling of fine particles. These effects lead to the accumulation of a high concentration of small particles in suspension which settle out on the banks of the estuary as mudflats. The waters of the Severn Estuary hold an estimated 10 million tonnes of suspended mud, thought to cycle between suspension and deposition on the intertidal mudflats.

Fine sediment particles behave very differently to larger sand particles. Fine particles have a large surface area relative to their small mass, and are attracted to one another by small electrostatic surface charges (Van der Waals forces), causing them to cohere together to form closely packed *cohesive* sediment beds. Larger sand particles are not influenced by these small charges, and this explains the difference between dry sand which runs freely and dry mud which forms a solid lump. The close packing of the small cohesive particles is an important feature of cohesive sediments and helps to define the physical nature of the environment for the organisms that inhabit such sediments.

The *porosity* of a sediment is a measure of the amount of space or voids between particles and is also related to the amount of water that the sediment bed can hold when it is fully saturated. Cohesive particles are small and closely associated, so the porosity of muddy sediments tends to be low. The sediment acts as an effective barrier to gas exchange, and so oxygen from the atmosphere cannot penetrate into the sediment. Several groups of *anaerobic* bacteria can survive without oxygen, and under these *anoxic* conditions they often produce toxic substances, such as ammonia or sulphur compounds. Scraping away the surface millimetres of brown oxic sediment often reveals a black, anoxic and unpleasant smelling layer where no oxygen has penetrated. This adds a further stress to sediment-inhabiting organisms, which must tolerate the toxic products of anaerobic bacteria.

LIGHT CLIMATE

Since the Severn is highly turbid, photosynthesis is limited in the intertidal area to the period of exposure during daylight hours. Light penetration through the closely packed sediment itself is very low and enough light to support photosynthesis only penetrates to a depth of about half a millimetre. Therefore, to allow photosynthesis to take place, diatoms must be at or near the sediment surface when the sediment is exposed during the day. The diatoms are highly adapted to this environment and are very efficient at utilizing low levels of light during the winter months or when the sediment is exposed at dawn or dusk. However, they can also be exposed to very high light levels during the summer when the sediment is exposed at mid-day. They show little or none of the *photo-inhibition* (inhibition of photosynthesis caused by high light levels) commonly suffered by higher plants.

NUTRIENT SUPPLY

Unlike the phytoplankton of surface waters, bottom-dwelling (*benthic*) diatoms are rarely limited by nutrient deficiency. The most important inorganic nutrients (phosphate and nitrogen) are generally plentiful in sediments, especially in polluted areas. Experimental fertilization of benthic sites has little influence on natural populations, except in regions unusually poor in nutrients. The more peculiar requirement for silica used in the laying down of the rigid cell walls is supplied by riverine sources and from the sediment itself.

ECOLOGY OF SEDIMENT-INHABITING DIATOMS

Patches of colour can often be seen on the surface of mudflats when the tide is out. These patches represent the accumulation on the sediment surface of thousands of individual cells. Diatoms contain the photosynthetic pigments Chlorophyll a and c and certain masking carotenoid pigments which tend to give the patches a golden-brown or, when dense, almost black appearance. Light or vivid green patches are more often caused by euglenid algae. Such patches can be seen from the Clifton suspension bridge on the muddy banks of the River Avon below. The patches are not always present, but develop fairly quickly after the tide retreats and exposes the sediment during daylight hours. Their appearance and disappearance is caused by the migration of diatom cells vertically within the sediment (Plate 1E, F). This strategy places cells at the surface when there is sufficient light for photosynthesis and removes them from the surface when the tide is in. There is little advantage in being at the sediment surface when the tide returns because: 1, the water is turbid, so sufficient light for photosynthesis cannot penetrate; 2, cells may be swept into suspension where they cannot photosynthesise and would die; and 3, fish and invertebrates often concentrate their grazing at the sediment-water interface.

DIATOM MIGRATION

Diatoms move by extruding mucilage through a slit in the valve, known as the *raphe* (Figure 1). Because the motion is driven by mucilage extrusion, the cells can only move when in contact with a surface: they cannot swim. The speed and pattern of movement seems dependent on the species and little is really known about how fast diatoms can travel through the sediment. Estimates on free surfaces fall within the range 1-25 μm s^{-1} (Edgar & Pickett-Heaps, 1984), i.e. 9 cm per hour. This may seem slow but in terms of body length (for a 20 μm diatom) it is equivalent to a 6ft human travelling at approximately 5 m.p.h., a reasonable jogging pace. Diatoms show a complex response to tidal and diurnal rhythms so as

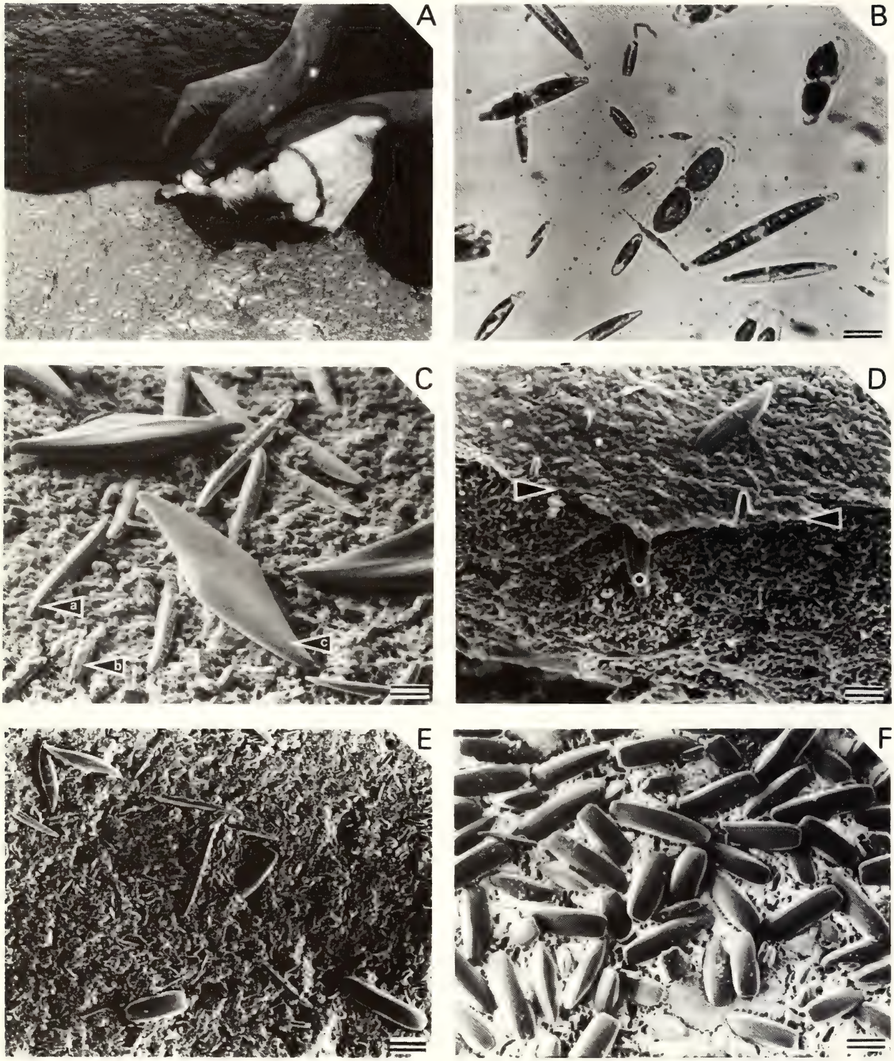

PLATE 1. A, sediment sample being taken from an intertidal mudflat for freezing and study by LTSEM. B, light micrograph of epipelic diatom community from Severn Estuary mudflat. C - F, LTSEM micrographs of surface of estuarine sediment. C, mixed community of diatoms; arrows indicate: a, *Gyrosigma* sp.; b, naviculoid diatom; and c, *Pleurosigma angulatum*. D, fracture face of sediment (fracture edge arrowed); above the fracture a *Gyrosigma* sp. cell can be seen on surface, while black spot indicates a cell beneath sediment surface. E and F, sediment during upward migratory phase of diatoms (mainly *Scolioneis tumida)*; E, some *S. tumida* have emerged, along with *Gyrosigma* spp.; F, later stage in migration, when many more *S. tumida* have emerged. Bar scales: B, 10 µm; C, 30 µm; D-F, 35 µm.

to place themselves at the surface of the sediment when the tide is out and when there is sufficient light for photosynthesis. One explanation of this complex behaviour is based on the interaction of two separate rhythms: 1, migration linked to the tidal cycle, which on its own would result in cell migration to the sediment surface when the tide goes out; and 2, a day/night rhythm which overrides this and prevents the upward migratory response during the night (Round, 1981).

DIATOM DISTRIBUTION ON MUDFLATS

Seaweeds on intertidal rocky shores exhibit a characteristic pattern of vertical distribution related to tidal influences. This pattern of zonation is well recognised for these large algae, but less is known about the spatial and seasonal distribution of micro-algae, such as diatoms, especially within soft sediments. The occurrence of epipelic diatom populations has been related to salinity, sediment type, exposure and pollutant levels, but no single factor has been shown to control the occurrence of epipelic species and little is yet known about the small-scale patchiness of diatom populations. The distribution of diatoms does, however, change seasonally and to a certain extent with varying salinity, some species being able to penetrate further up an estuary than others, e.g. *Navicula salinarum* (Admiraal, 1984), but the relationship between diatom populations and environmental factors is complex.

RECENT STUDIES AT BRISTOL UNIVERSITY

Although some work has been carried out on the spatial and seasonal distribution of epipelic diatoms on estuarine mudflats (Admiraal, 1984), no comparable studies have been undertaken on the Severn Estuary. The work described below outlines a study of epipelic diatoms carried out at Aust during 1990-1991. The objective of this research was to identify the dominant diatom species, and to observe the changes in their abundance due to tidal influence and seasonal variation.

METHODS

Diatom communities were sampled from the upper (mean high-water neaps), middle (mean tide) and lower (mean low-water neaps) shores at Aust, about 1 km south of the Severn Bridge. Diatoms were collected by leaving a double layer of lens tissue on the sediment surface for one hour. During their migration phase, the diatoms move upwards into the lens tissue (Eaton & Moss, 1966). The upper piece of tissue, containing a relatively sediment-free sample of diatoms, was then removed and examined. Samples were taken at approximately monthly intervals from March 1990 to February 1991. The distribution and abundance of the diatoms on the surface of the mudflat was compared using a statistical technique known as principal components analysis (PCA) to differentiate community structure.

RESULTS

Over sixty diatom species were identified during the year, the ten most common being *Navicula salinicola* Hustedt, *N. flanatica* Grun., *N. menisculus* Schumann, *Nitzschia epithemioides* Grun., *Raphoneis minutissima* Hustedt, *Cylindrotheca signata* Reimann & Lewin, *Stauroneis amphioxys* Greg., *Gyrosigma spencerii* (W.Smith) Cleve., *Amphiprora paludosa* van Heurck and *Coscinodiscus* spp.

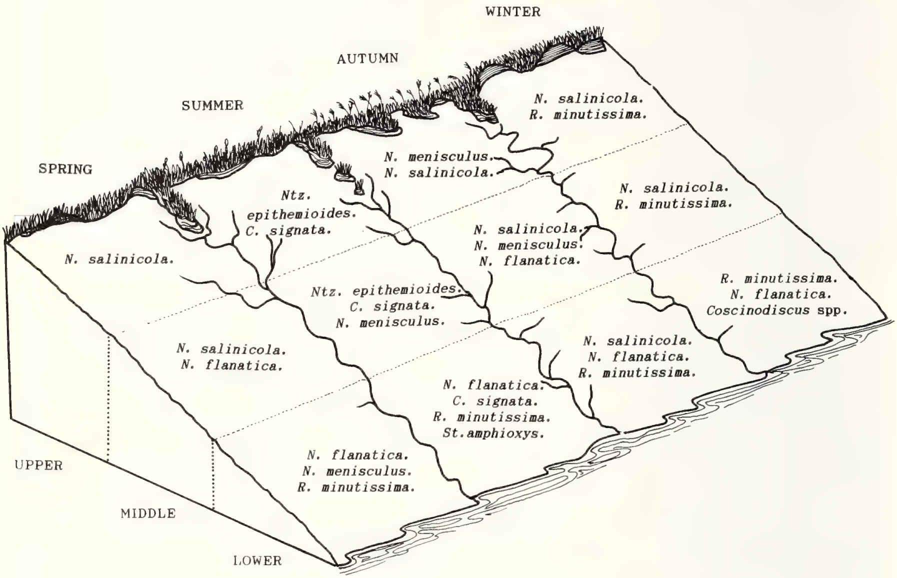
WINTER
AUTUMN
SUMMER
SPRING
N. salinicola.
R. minutissima.
N. menisculus.
N. salinicola.
N. salinicola.
R. minutissima.
Ntz. epithemioides.
C. signata.
N. salinicola.
N. salinicola.
N. menisculus.
N. flanatica.
R. minutissima.
N. flanatica.
Coscinodiscus spp.
Ntz. epithemioides.
C. signata.
N. menisculus.
N. salinicola.
N. flanatica.
N. salinicola.
N. flanatica.
R. minutissima.
N. flanatica.
C. signata.
R. minutissima.
St. amphioxys.
N. flanatica.
N. menisculus.
R. minutissima.
UPPER
MIDDLE
LOWER

FIGURE 2. A schematic representation of the occurrence of diatom species throughout the year at different heights on the intertidal mudflats at Aust on the Severn Estuary. The most dominant species are given in order of abundance for each period of the year. Where more species are given the community was more variable within the season.

The broad results of statistical analysis (PCA), summarised schematically in Figure 2, showed the most important species at each sample time and at each position on the shore. Both the upper and mid-shore communities showed seasonal changes, with *Navicula salinicola* dominant during spring 1990. *Nitzschia epithemioides* became dominant in summer, with an increasing proportion of *Navicula meniscuius* towards the autumn on both upper and mid-shore sites. Winter saw a return to communities dominated by *Navicula salinicola*, whilst in February (after a period of storms) the upper shore was colonised by an unusual number of *Raphoneis* and *Coscinodiscus* as well as the dominant forms. Community composition varied less at the low-shore sites than at the higher sites: in every sample *Navicula flanatica* and *R. minutissima* were a significant fraction of the total, and they were dominant in all months except during the autumn, when a bloom of *Navicula salinicola* occurred.

Upper and mid-shore communities showed general seasonal trends: communities were dominated in winter by *N. salinicola* and in summer by *Nitzschia epithemioides* and *Navicula meniscuius*. Low-shore assemblages showed less seasonal change and were dominated by *R. minutissima*, *N. flanatica*, *N. meniscuius* and *Coscinodiscus* spp.

CONCLUSIONS

ZONATION

There was no clear zonation of diatom species with height on the shore, as occurs with the larger seaweeds found on rocky shores. *Navicula salinicola* was dominant at some time at all levels and *Raphoneis minutissima* was also cosmopolitan in distribution. *Navicula flanatica* was always an important part of the community at low-shore sites and occasionally at mid-tidal levels but was never dominant higher on the shore, so some aspect of exposure stress may influence its distribution.

SEASONALITY

The results of the PCA analysis demonstrate that the upper and mid-shore communities follow seasonal changes in composition. The low-shore communities do not follow this clear trend. The major difference between these communities is the period of tidal exposure that each experiences. As the exposure period increases, atmospheric effects, such as drying out, temperature variation and salinity changes, become more severe. On rocky coasts, the increasing severity of physical effects has been shown to control the upper limits of seaweed zonation (Lobban *et al.*, 1985). Diatoms are very different in life strategy from the larger seaweeds but must also cope with the stress inherent in longer exposure periods.

The finding that the mid and high-shore communities vary with the seasons points to a strong atmospheric influence on the composition of the epipelic populations. The low-shore communities do not experience such great atmospheric stress because they are buffered by frequent flooding. Instead, low-shore communities must be adapted to cope with long periods when photosynthesis is impossible, and with a sediment substrate that is usually unstable. Adaptation to low-shore conditions may therefore depend less upon seasonal factors than is the case at high-shore sites; this is reflected in the analysis.

Diatoms are important components of the estuarine system and, particularly in turbid estuaries, epipelic forms assume a greater role in maintaining mudflat productivity. The carrying capacity of an estuary as a feeding ground for fish and birds partly depends upon organisms such as the ragworm (*Nereis diversicolor*) and the mud snail (*Hydrobia ulvae*) which in turn feed on benthic diatom populations. Further work is required to give a full understanding of the importance of diatoms as part of the food web in estuarine systems, their relationship with other microbial forms such as bacteria and protists, and their importance as a food resource for organisms ranging from protists and nematodes to bottom-feeding fish.

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ANIMALS OF SEVERN ESTUARY SALT MARSHES

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INTRODUCTION

To many, the Severn Estuary appears to be fringed by normal grazing pastureland. Cows and sheep crop the sward and can be seen ankle deep at the edge of the mudflats. Fields outside the sea wall, however, have very special plant communities, tolerant of immersion in salt water and of the deposition of layers of soft mud as the silt-laden waters of the Estuary creep over them at high tide. Within this vegetation, particularly on the few ungrazed marshes, lives a very specialised and fascinating collection of invertebrate animals. On the higher levels, birds and mammals use the marshes and may have important effects on the ecosystem. Although several texts describe the salt marsh flora, there are surprisingly few accounts of salt marsh faunas in Britain (see Long & Mason, 1983; Adam, 1990). In this article I shall give an account of some of the commoner animals on salt marshes within the Severn Estuary, and how they interact.

CHITTENING WARTH

VEGETATION

Most research on salt marsh invertebrates in the Severn has been carried out at Chittening Warth, near Avonmouth (Figure 4), and I shall start by describing the distribution of the common species there. Although this marsh is near to an industrial complex, it is isolated from industry by a railway embankment, and the adjacent mudflats are well known as wader feeding grounds (Thomas, 1981). The marsh itself is ungrazed.

The three levels of the marsh correspond to three ages of formation (Allen, 1987) and have different vegetation dominants (Figure 1; see Beckett, 1986). On the top level, the Rumney Surface, which is flooded by only a few tides each year, the tall spikes of Sea Couch-grass (*Elymus pycnanthus*, formerly *Agropyron pungens*) cover most of the ground. On the middle level, the Awre Surface, a mixed sward of Sand Couch-grass (*E. farctus*), Red Fescue (*Festuca rubra*) and Sea Aster (*Aster tripolium*) is found. The lowest part of the marsh, the Northwick Surface, which was formed more recently and slopes more steeply, has a more diverse flora but is dominated by Common Saltmarsh-grass (*Puccinellia maritima*) and Common Cord-grass (*Spartina anglica*). In early spring and summer, much of the lower marsh may be covered by Long-leaved Scurvy-grass (*Cochlearia anglica*) but this dies down in the autumn.

In contrast, those marshes that are grazed by sheep or cattle, such as that at Northwick just upstream, have less plant diversity but show the appearance of other dominants, such as Glasswort (*Salicornia spp.*), at various times of year.

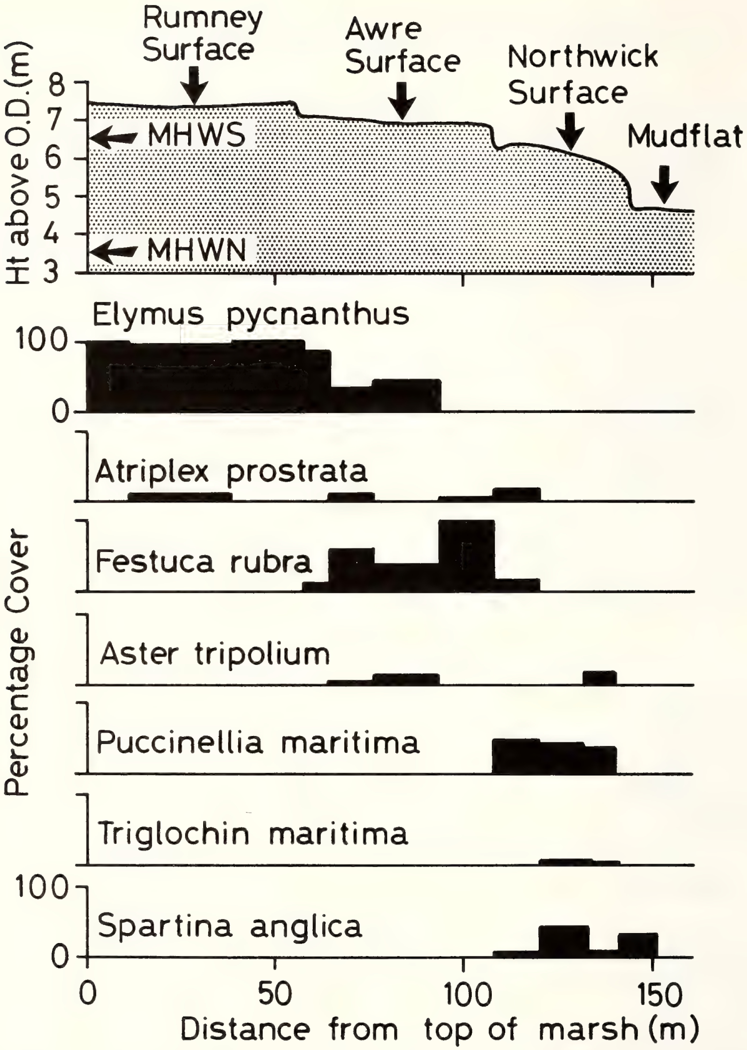

FIGURE 1. A profile of the marsh at Chittening Warth, and histograms showing the distribution of major plant species along a transect line. Arrows show the heights of mean high water spring tides (MHWS) and mean high water neap tides (MHWN). Nomenclature of Surfaces from Allen (1987). After Beckett (1986).

Marshes further down the Estuary show different dominants near their landward edge: much of the high marsh in Sand Bay is covered by Hastate Orache (*Atriplex prostrata*); and in Bridgwater Bay there is often Common Reed (*Phragmites australis*) at the top of the marsh.

INSECTS AND SPIDERS

Perhaps the most obvious of the invertebrates are the insects. Table 1 gives a list of those recorded as common at Chittening by Little *et al.* (1988). The first to make themselves evident may well be the dull brown clegs, *Haematopota pluvialis*, which are as common on the marsh as they are on inland pastures. Many syrphid flies are present, and the scathophagid *Scathophaga litorea* is a salt marsh specialist. Crickets are common on the upper marsh, and mirid bugs, frog-hoppers and leaf hoppers are found at all levels. Particularly on the upper levels of the marsh, there are many terrestrial insects, ranging from butterflies to bumblebees. These top levels are seldom covered by the tide in summer, and terrestrial colonists treat them like normal meadows.

TABLE 1. Insects and spiders recorded as common at Chittening Warth (from Little *et al.*, 1988). Note that the beetle *Heterocerus maritimus* is also common, but requires digging to find.

HEMIPTERA - HETEROPTERA
- MIRIDAE (capsid bugs)
    - *Calocoris norvegicus*
    - *Capsus ater*
    - *Leptopterna ferrugata*
- SALDIDAE (saldid bugs)
    - *Saldula palustris*

HEMIPTERA - HOMOPTERA
- CERCOPIDAE (spittle bugs)
    - *Philaenus spumarius*
- CICADELLIDAE (leaf hoppers)
    - *Streptanus sordidus*

COLEOPTERA
- CARABIDAE (ground beetles)
    - *Dyschirius salinus*
    - *Bembidion minimum*
    - *Bembidion aeneum*
- CANTHARIDAE (cantharid beetles)
    - *Cantharis nigra*
- COCCINELLIDAE (ladybirds)
    - *Tytthaspis 16-punctata*
- CHRYSOMELIDAE (leaf beetles)
    - *Phaedon coccinus*

DIPTERA
- TABANIDAE (horse flies)
    - *Haematopota pluvialis*
- SYRPHIDAE (hover flies)
    - *Melanostoma mellinum*

ORTHOPTERA
- TETTIGONIDAE (bush crickets)
    - *Conocephalus dorsalis*

ARANEAE (spiders)
- *Pardosa agrestis*
- *Pardosa pullata*
- *Hydrolycosa rubrofasciata*
- *Tetragnatha montana*
- *Pachygnatha clercki*
- *Bathyphantes approximatus*

More salt marsh insects can be found on the mud surface beneath the grasses. Here are more of the bugs and a variety of beetles, as well as many spiders. The saldid *Saldula palustris*, the commonest bug, is a well-known predator of salt marsh invertebrates. The beetles are more varied, both in appearance and in lifestyle. The yellow-and-black 16-spot ladybird, *Tytthaspis 16-punctata*, a predator of aphids and other small insects, is common on the detritus of dead plant stems. (Note an error by Little *et al.*, 1988, who recorded *Thea 22-punctata* as common; it is rare, whereas *Tytthaspis 16-punctata* is common.) The shiny black carabids, with their ridged wing-cases, and the duller cantharids are common predators. The brightly coloured chrysomelids, often showing a metallic sheen, are abundant leaf-feeders. Besides these easily-found insects, there are the smaller ones. Springtails are common everywhere although, being sometimes only a millimetre long, they are often ignored. One tiny beetle particularly well adapted to life on salt marshes is the small brown *Heterocerus maritimus*. It is occasionally found on the surface of the mud, but often it can only be located by its burrows. These are shallow horizontal chambers, and the beetle uses its shovel-shaped front legs to dig through wet mud, leaving a characteristic raised trail of fine pellets above the burrows. Where there is little vegetation these trails may dominate the mud surface, and the beetles may easily be found by shallow digging.

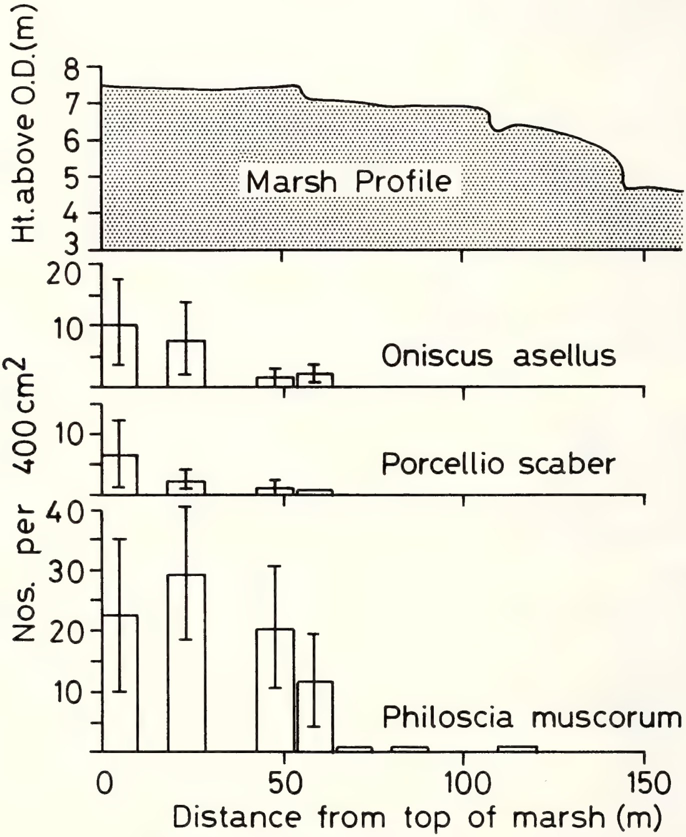

FIGURE 2. Distribution of three isopod Crustacea on the surface of the marsh at Chittening Warth in 1985. Histograms show mean values of six quadrats. Vertical bars show standard deviation. After Marven (1986).

Running over the marsh, and in summer even exploring the mudflats, are numerous spiders. Species such as *Pardosa agrestis* are common at all levels of the marsh, and hunting spiders are certainly important predators as far as the insects are concerned. There are also many web-spinners (the Linyphiidae) at all levels. Unfortunately, little is yet known about the ecology of the spiders on the marsh.

OTHER INVERTEBRATES

Hidden in the vegetation, or on the mud beneath it, is a wealth of other invertebrate life besides the insects and spiders. The isopod Crustacea (woodlice) give a good introductory picture (Figure 2; see Marven, 1986). Three species of terrestrial woodlice are common. Each is more abundant at the top of the marsh, but one (*Philoscia muscorum*) is also found in small numbers down to the seaward edge, on the Northwick Surface. Here it hides in clumps of *Plantago* and *Triglochin*, which may retain sufficient air pockets to allow it to breathe over the high tide period.

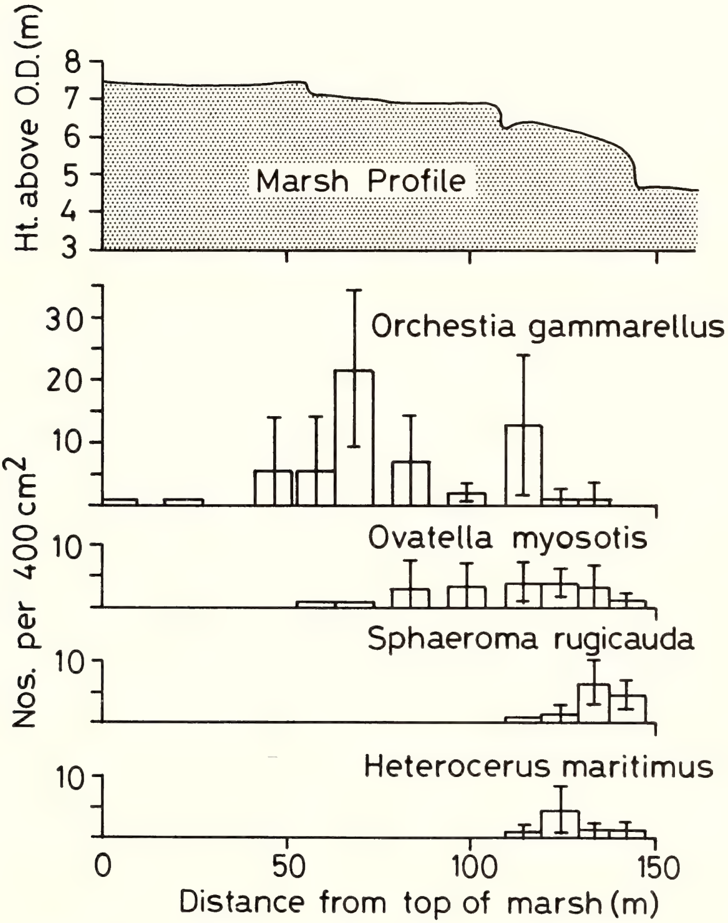

FIGURE 3. Distribution of four invertebrates on the marsh surface at Chittening Warth in 1985. Histograms show mean values of six quadrats. Vertical bars show standard deviation. Note that *Sphaeroma* is also found higher up the marsh, in pools. After Marven (1986).

A fourth species, *Sphaeroma rugicauda*, is an aquatic isopod (Figure 3). It curls into a muddy ball when out of water and until disturbed may be hard to recognise as an animal. Its distribution is limited to the seaward fringe of the Northwick Surface, although it is often found swimming in pools higher up the marsh. For these four species, coverage - or non-coverage - by the tide must be one of the major factors governing distribution.

ECOLOGY OF TWO COMMON SPECIES

For many species on the marsh, other factors may be just as important as the tide, and the complexity of the situation is illustrated by two of the commonest species.

On the middle levels of the marsh, by far the commonest crustacean is the amphipod (beach hopper) *Orchestia gammarellus* (Figure 3; Marven, 1986). Many individuals walk on the mud surface, but to find large numbers it is necessary to disturb the swathes of dead *Spartina* and seaweed that form the drift lines. Thousands of hoppers then spring in all directions. Also in the middle marsh, but not limited to the strand line, is the small pulmonate snail *Ovatella myosotis*, which crawls over the mud surface when it is wet but retreats into cracks and crannies when it dries out. The distribution and ecology of these two species, perhaps the most abundant and most easily found of all the aquatic species on the marsh, are discussed briefly below.

Orchestia gammarellus

This species is well known from strand lines on rocky shores as well as on salt marshes. It eats decaying algae and *Spartina*, and spends most of its time out of water. Like other amphipods, it desiccates easily when exposed to dry or moving air (Morritt, 1987), and in nature it restricts its activity to night time (Morritt, 1988) when temperature is low and humidity is high. In the laboratory, it has been shown to move into more humid air from dry air, and at least in part this arises because it is very active in low humidities, but becomes less active when it moves into a nearly saturated atmosphere. It is referred to as a typical "cryptozoic" animal - one that lives hidden in crevices and so experiences a constantly humid environment.

Ovatella myosotis

This insignificant spindle-shaped pulmonate snail can reach high densities on the marsh. Several hundreds may occur in a square metre (Morritt, 1985), although the highest average density recorded in this survey was 100 per m^2 (Figure 3). It breathes air through a lung, like terrestrial snails, but is also able to withstand long periods under water, possibly taking in oxygen directly through the skin. Like *Orchestia* it is a detritus feeder, but it concentrates on the mud surface rather than in decaying seaweed. Low down the marsh, many may be found clustered amongst the bases of *Plantago maritima*. The densely packed leaf rosettes of this plant offer an ideal refuge from desiccation, while the roots provide crevices that are used for burrowing down into the soil during winter (Morritt, 1985).

One other species that is common at Chittening - but only in summer - is the tiny opisthobranch mollusc *Limapontia depressa*. This may be seen as a glistening, dark green blob crawling on the mud surface of the lower marsh. It eats the moss-like alga *Vaucheria* spp. and its distribution may be limited by this as well as by its intolerance of desiccation.

Chittening Warth thus has an abundance of invertebrate types. Other marshes, however, show some quite significant differences, and give us an insight into further factors controlling animal distribution.

OTHER SALT MARSHES

Salt marshes reach up the Estuary as far as Sharpness, and there are fragments of marsh even at Hock Cliff (near Frampton-on-Severn). The last large marsh downstream towards the Bristol Channel is in Bridgwater Bay. Little *et al.* (1985) and Little *et al.* (1988) examined four other marshes in this stretch, in addition to Chittening Warth: Sharpness, Aust, Sand Bay and Bridgwater Bay. They found 137 species of insects and 7 species of spiders. The three most abundant insect orders were Coleoptera (54 spp.), Diptera (45 spp.) and Hemiptera (24 spp.). The distribution of these is shown in Figure 4, from which there appear to be no obvious trends that correlate with distance up or down the Estuary. Instead, each marsh has its own characteristic species list, and Little *et al.* (1988) suggested that the drainage of each marsh and its soil type and profile may have more influence on the insect fauna than, say, salinity, which increases progressively from Sharpness to Bridgwater Bay.

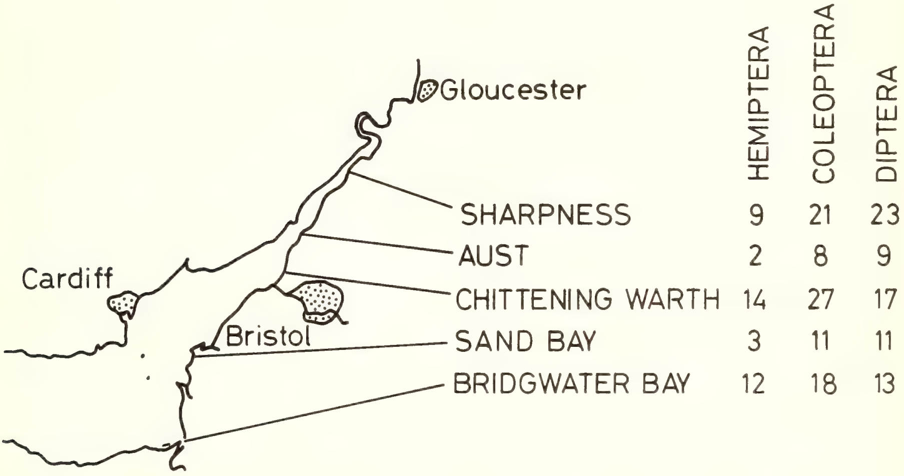

FIGURE 4. Distribution of major insect orders at five salt marshes on the southern shores of the Severn Estuary. Data from Little *et al.* (1988).

The marsh in Sand Bay contains one species of particular interest not found at Chittening. The lower edge of this marsh consists of long projecting fingers that alternate with deep drainage creeks. The tops of the fingers have patches of vegetation, but also widespread areas of bare mud in which beetle burrows are common. The most prominent burrows are those of a staphylinid, *Bledius spect-*

abilis, easily distinguished by its bright red elytra. This species has been studied in detail by Wyatt (1986). It digs quite deep burrows into the mud, and there lays its eggs in separate little chambers. When the larvae hatch they continue to live in the burrow and the whole family is looked after by the mother beetle. She cleans fungi from the eggs, closes the burrow when the tide covers the marsh and opens it again when the tide recedes. She also defends her brood against predators, such as another common beetle, *Dicheirotrichus gustavi*. Without her help, very few young would survive. Care of the young is rare in insects, apart from in the social species, and seems to have evolved in this case as a response to the harsh conditions at the edge of the marsh (Wyatt, 1986).

The predator *D. gustavi* is a carabid beetle, again well studied because it is a salt marsh specialist (e.g. Treherne & Foster, 1977). It emerges from crevices in the soil only at night time, and only when the tide is out. This activity pattern ensures that the beetle avoids drowning and coordinates its activity with that of prey species. Activity is governed by an internal "circadian" (day/night) rhythm which is suppressed when the tide covers the marsh. The beetle is therefore able to predict when conditions are favourable without having to come to the marsh surface.

WHO EATS WHOM ON CHITTENING WARTH?

One way of trying to understand a specific ecosystem is to work out the food webs or food chains - which species eats which others and where each gets its energy from. For a marsh such as Chittening Warth, it is possible to make some very preliminary attempts at sketching out a foodweb, although most of the links require much more investigation. Figure 5 shows some of the commonest animals, with an indication of where they are to be found. They have also been placed in a specific trophic level, in other words categorised as: herbivores - eating living plants; detritivores - eating dead and decayed organic material; or carnivores - eating living animals.

Some of the most common invertebrates are detritivores, eating the plentiful organic material derived from the plants that make up the marsh. Many are of marine origin - for instance, the snail *Ovatella* and the crustaceans *Sphaeroma* and *Orchestia*. In contrast, the beetle *Heterocerus* and the woodlouse *Philoscia* undoubtedly have terrestrial ancestors, and indeed *Philoscia* would normally be expected in purely terrestrial habitats.

For an environment in which plants are dominant, there are surprisingly few common herbivores shown in Figure 5. In part this is an artefact because, while few herbivore species are as common as detritivore species, there is a wide diversity of herbivores, particularly insects (Little *et al.*, 1988). In other words, there are just a few detritivore species, but each is very common; while there are many herbivore species, but each is relatively rare. The exceptions are the frog hopper, *Philaenus*, which sucks sap from various angiosperms, and *Bledius* and *Limapontia*, both of which eat algae (although of different kinds). *Bledius* scrapes up micro-algae from the mud surface, while *Limapontia* crawls over and eats the filamentous strands of *Vaucheria*.

A wide diversity of insect predators takes advantage of the animal food supply on the marsh, although here it is not at all certain which species feeds on which. The ladybird *Tytthaspis* probably takes small insects such as aphids (not shown on the

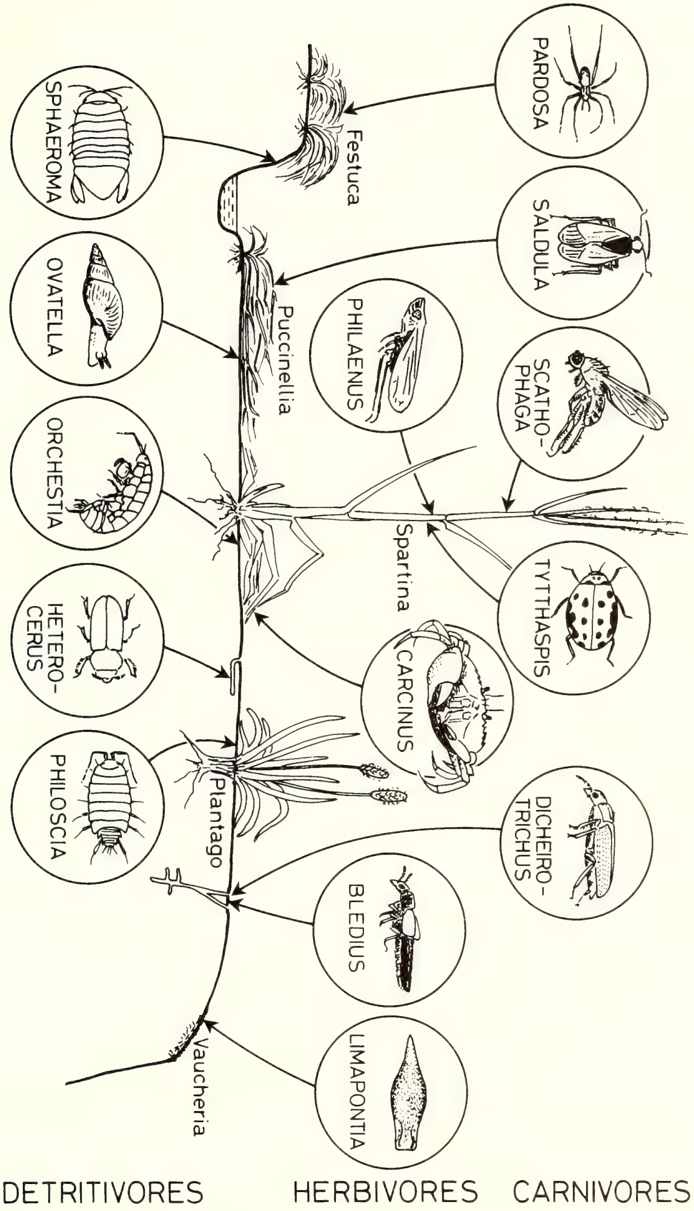
SPHAEROMA
OVATELLA
ORCHESTIA
HETEROCERUS
PHILOSCIA
Festuca
Puccinellia
Spartina
Plantago
Vaucheria
PHILAENUS
CARCINUS
BLEDIUS
LIMAPONTIA
PARDOSA
SALDULA
SCATHOPHAGA
TYTTHASPIS
DICHEIROTRICHUS
DETRITIVORES
HERBIVORES
CARNIVORES

FIGURE 5. Diagram showing some of the common invertebrates found on the lower levels of salt marshes in the Severn Estuary. Animals are placed in one of three trophic levels: detritivores below, herbivores in the centre, and carnivores at the top. Note that *Carcinus maenas* is part herbivore and part carnivore.

diagram because they have not been investigated, but they are almost certainly widespread). *Dicheirotrichus* feeds principally on the larvae of *Bledius*. *Scathophaga, Saldula* and the spiders are doubtless insect predators, but their role in Severn Estuary marshes has never been defined.

It is easy to be trapped into the idea that the dominant animals found in a survey are the important ones. In the case of the Severn Estuary marshes the resident invertebrates discussed are certainly important, but they are accompanied by many visitor species, both invertebrate and vertebrate. At high tide the shore crabs, *Carcinus maenas*, invade the marsh from the mudflats. They are really omnivores, but probably have their greatest effect as predators of small molluscs and crustaceans. There may also be fish which come in at high tides. Certainly mullet move up the mudflats eating surface algae, and they probably graze the edge of the marsh. At low tide (the predominant state for salt marshes) and particularly at night, terrestrial vertebrate predators arrive. The highest levels of the marsh at Chittening are crowded with voles, and barn owls have been seen at dusk. Foxes also raid all levels of the marsh. In the daytime, it is common to disturb snipe on the marsh, and these often feed by probing into the marsh mud. The overall effect of these vertebrate predators has not been defined, but they add an extra dimension of complexity to the marsh ecosystem. At all stages of the tide, day and night, the salt marsh is far from the normal pastureland that it appears.

ACKNOWLEDGEMENTS

I am indebted to Dr D. Morritt for permission to quote from his unpublished work. Much of the information on distribution of insects was gained during a project supported by the Hector Hockey Fund of the Bristol Naturalists' Society, and I am very grateful for this support. I particularly thank Mr R. M. Payne who undertook or confirmed most of the identifications of insects during this study. Dr D. Morritt, Dr M. H. Martin and Mr R. M. Payne kindly commented on the manuscript.

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APPENDIX

THE IDENTIFICATION OF SALT MARSH ANIMALS

Identifying the animals found in salt marshes is not particularly easy. Zoologists usually recognise animals as terrestrial, freshwater or marine, and design their identification guides accordingly. Salt marsh faunas fall right where these boundaries join. However, it is often possible to identify to animal group quite easily. Below are some hints on how to make a start.

INSECTS are probably best approached first with a general guide such as M. Chinery's *A field guide to the insects of Britain and Northern Europe* (Collins, 1976). This will take you to family. After that, specialist keys must be used, the best being the *Handbooks* produced by the Royal Entomological Society of London. Some groups (e.g. water beetles, Diptera, Coleoptera, general terrestrial invertebrates) have been covered by the AIDGAP publications of the Field Studies Council (contact "Field Studies", Nettlecombe Court, Williton, Taunton TA4 4HT). It is often *not* easy to be sure of identifications, and you may need to seek professional advice.

SPIDERS are also not at all easy to identify to species. The latest detailed book is M.J. Roberts' *The spiders of Great Britain and Ireland* (Harley Books, 1985). This is large and rather expensive. As with insects, specialist advice may be necessary.

WOODLICE, on the other hand, can readily be identified from the key and pictures given by S.L. Sutton in *Woodlice* (Pergamon Press, 1980).

The so-called "MARINE" INVERTEBRATES are quite diverse, and include MOLLUSCS, ANNELIDS, CRUSTACEANS and others. The best general guide to start with is by J. H. Barrett & C. M. Yonge, *Collins pocket guide to the seashore* (Collins, 1958). After that, there is a bewildering complexity of guides and books for particular groups. The best series is that of the *Synopses of the British fauna* produced by the Linnaean Society of London and the Estuarine and Coastal Sciences Association (present publisher Universal Book Services/Dr W. Backhuys. For information about membership of ECSA, contact Dr P. C. Head, North West Water Ltd., Dawson House, Great Sankey, Warrington WA5 3LW). In addition, some of the guides published by the Freshwater Biological Association, although quite old, are still relevant (e.g. pulmonate gastropods); contact the FBA, The Ferry House, Far Sawrey, Ambleside, Cumbria. For amphipod crustaceans, see R.J. Lincoln's *British marine Amphipoda: Gammaridea* (British Museum (Natural History),1979).

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BIRDS OF THE AVON SHORE

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INTRODUCTION

One of the most obvious wildlife aspects of the Avon shore is its birds. Even the most casual observer will notice the gulls, some Shelduck, large Dunlin flocks during the winter months, Starlings, and many other small birds, including Skylarks and finches. A more detailed study will reveal the rich bird life of the area. At least 250 bird species have been recorded this century on or near the shore, ranging over all the main avian groups. Of these about 140 can be described as common or regular. Some species occur in very large numbers, mainly Dunlin, Black-headed Gull and Starling, and occasionally Wigeon, Lapwing, Fieldfare and Chaffinch. Although not occurring in thousands there are also important numbers of Shelduck, Mallard Curlew, Redshank, Turnstone, Wheatear and Linnet. A number of species nest in the area but the breeding density is generally low and declining. One reason for this is the considerable disturbance of all kinds to which the area is subjected.

DESCRIPTION OF THE AREA

The Avon shore extends from Oldbury in the north to the edge of Brean Down in the south-west. Extensive mud flats and banks with some areas of rock, shingle and sand border the waters of the Severn. The amount of exposed mud varies from virtually nothing to several thousand hectares every six hours. The mud and shingle banks are continuously on the move due to the extreme force and range of the tides, and as a consequence very little vegetation that requires to be firmly rooted can establish itself. Fifty years ago there were some large areas of *Spartina* on the mud flats; in some parts of the shore this is now diminished, partly because planting has stopped (see Martin, 1992). Behind these mud flats are large and elaborate sea defences consisting of substantial earth banks and concrete walls which have frequently been strengthened and improved; this was especially so during the 1980s after a major flood in December 1981. They are an important wildlife habitat, providing good roost sites for the waders and other water birds, and rough grass and shingle areas for passerines such as Wheatear and Linnet. Apart from the urban conurbations, the land behind the sea walls is mainly a flat alluvial plain at or below sea level, and given over to pasture. Some rock outcrops do occur; the most extensive area between Portishead and Clevedon is ornithologically uninteresting and not often visited, but smaller outcrops at Sand Point and Steep Holm are of considerable interest for their bird life.

SOURCES OF INFORMATION

The ornithology of the Avon shore is well documented and the purpose of this paper is to give a brief summary; readers seeking details should consult the sources used. The main source is the *Avon Bird Report* and its predecessors which have been published annually since 1936, first by the Bristol Naturalists' Society (Davis, 1937-1952, 1956-1974; Davis & Chadwick, 1953-1955; Taylor, 1975-1983) and since 1983 by the Avon Ornithological Group (Taylor, 1984-1991). Survey papers on particular bird groups or sites are listed in the references. The annual reports of the national Birds of Estuaries Enquiry (Anonymous, 1972 onwards) have included counts from Avon from its inception in 1971; the Enquiry now includes wildfowl counts for the national wildfowl census scheme, based at Slimbridge. Palmer & Ballance (1968) summarised older information for the coast south-west of Bristol.

The birds of the Avon shore are considered here under four main headings: sea-birds (mainly the gulls), wildfowl, waders, and land birds. The first three of these categories are important for the site, but the last is mainly concerned with birds chiefly occurring inland and occasionally seen on or near the shore.

SEABIRDS

The seabirds of the Avon shore and the Severn Estuary fall into two quite separate categories. The first contains only a few species though in very large numbers, and they are present for much of the year; the Black-headed Gull is the most obvious example. The second category contains at least thirty species, including the terns; normally they appear singly or in small groups during unusual or freak weather conditions, e.g. an autumn south-westerly gale may produce a few skuas or petrels. Neither category generally feeds on or in Estuary waters; the regularly occurring species feed mainly inland and use the shore and the waters nearby for loafing and roosting. The remainder are either migrating or have been displaced by storms.

COMMON AND BREEDING SEABIRDS

Just four species breed, and these only in relatively small numbers; none can really be counted as shore breeders. Avon's one Cormorant breeding colony is on the north cliff face of the island of Steep Holm and in most summers holds 20-50 pairs; exact numbers are difficult to ascertain as a special boat trip around the island is needed for a precise census, but a rough estimate can be made from the island itself. Cormorants are clearly able to take fish from the Estuary, where they are the only diving species to feed regularly. Even so, many commute between the Estuary and the main Avon reservoirs to feed, and this is when they are most often seen from the shore. (Counts of Cormorants at Chew Valley Lake regularly exceed 50 and the highest count during 1990 was 149.)

The three large gull species also breed: Great Black-backed Gulls only on Steep Holm and the Denny (normally less than 30 pairs at each site); large numbers of Herring and Lesser Black-backed Gulls breed on the Holmes, and a few on certain coastal cliffs, e.g. Wain's Hill at Clevedon. Recently Herring and Lesser Black-backed Gulls have begun to breed on the roofs of some high buildings in the centres of conurbations near the coast, including Bristol, Bath and Portishead, as well as other towns outside Avon. During the present century, up to 1975, the breeding numbers on the Holmes and the rest of the Severn Estuary increased dramatically, but since then numbers have dropped markedly due to a form of botulism poisoning (probably picked up from rubbish tips - a favoured feeding place - although the exact origin has not been established). At their peak there were 8,100 pairs of Herring Gulls and 590 pairs of Lesser Black-backed Gulls on Steep Holm alone (see Mudge & Ferns, 1980).

The commonest gull species occurring along the Avon shore is the Black-headed Gull. A few hundred, mainly immature individuals, are present in spring and early summer but outside this period very large flocks are regularly seen, and the total population using the shore ranges between 10,000 and 40,000 birds. The species does not breed in the area (although there have been a few attempts) and the nearest breeding colonies are in South Wales, *c.*100 km to the north-west. Most birds feed inland, mainly on farmland, rubbish tips and along the River Avon and minor rivers, and return each day to the coast to roost. There are five main roost sites along the Avon shore: Oldbury (2,675), Avonmouth (4,900), Clevedon (520), Woodspring Bay (1,360) and the mouth of the Axe south of Weston (1,500); the bracketed figures are the numbers of Black-headed Gulls recorded during the last gull roost survey in January 1980. A major inland roost site is at Chew Valley Lake, where 17,650 birds were counted in 1980 (see *Avon Bird Report* for 1980).

The fifth gull species seen regularly is the Common Gull, but in our area this is mainly an inland species, whether feeding or roosting. In cold weather flocks of several hundred birds move to the coast to feed and roost, but for most of the year only a few birds are present on the shore and the species does not breed in the area. Some are seen on migration, and in May small flocks of 20-80 immature birds appear; the reason for these occurrences is not known (see Vernon, 1969).

IRREGULAR MIGRANTS AND STORM-DRIVEN BIRDS

The most important of the irregularly occurring species are Manx Shearwater, Kittiwake, and Common and Arctic Tern. Very large breeding colonies of Manx Shearwaters on the islands off the Pembrokeshire coast contain in some years over 140,000 pairs. During the summer months flocks from these colonies, sometimes up to 250 or more, are recorded off the Avon shore. They mainly occur with strong westerly or south-westerly winds; as far as is known, the birds do not feed in the upper Estuary and return to the outer Estuary as soon as conditions permit. The Kittiwake has been recorded in all months, although it does not usually occur with the other pelagic birds during autumn storms. The largest flocks, sometimes up to 600 or more, are seen in winter and early spring; some are storm-driven but others are probably migrants heading north-east for the North Sea and beyond.

No species of tern can be regarded as regular along the Avon shore and in some years only a handful are recorded; a few may occur during autumn storms. Occasionally, in late April and May, large flocks are seen passing up the Estuary offshore, with some resting inshore; in spring 1990 over 6,500 terns were seen. Common Terns predominate at first, whilst Arctic Terns become more regular by mid-May. The other tern species are much less common, although flocks of 100 or more Black Terns have been seen along with the sea terns. These movements are associated with anticyclones and their resulting north-east winds, when the migrating flocks keep low, often flying only a few metres above the waters of the Estuary. In most years these anticyclonic conditions do not occur, and the prevailing winds are from the west; it is thought that the birds take roughly the same route but fly at altitude (perhaps as high as 5km) and so are not seen. Alerstam (1990) covers the latest theories on bird migration.

Major Atlantic storms are a regular feature of autumn and often bring gale force westerly winds into the Estuary. A wide range of pelagic seabirds have been recorded close to the shore during such conditions. The best vantage point in Avon is at New Passage, where the Estuary is narrow enough for observation across to the opposite shore. Birds treat the Severn Bridge, 2km north-east of New Passage, rather like a large cliff and tend to congregate on or over the waters of the Estuary to its seaward side - behaviour that may change when the second bridge is built. Besides those mentioned above, the main species seen during these storms include Storm and Leach's Petrel, Fulmar and Gannet, Arctic, Pomarine and Great Skua, Sabine's Gull and the auks - although Puffin is very rare. These appearances are unpredictable, depending partly on the timing and the exact track of the storms in the Western Approaches; they can be very dramatic, as with the wreck of Leach's Petrels in October and November 1952 (Boyd, 1954). Lancastle (1990) detailed seabird occurrences in the upper Estuary for the previous fifteen years.

WILDFOWL

As with the seabirds, only a few species of wildfowl occur regularly with relatively large populations along the Avon shore, whilst most ducks, geese and swans on the British list have appeared as migrants or irregular visitors at some time during the past half century. Most diving ducks have great difficulty locating prey due to the turbidity of the water and so are obliged to move elsewhere. The extreme force and range of the tides precludes much under-water rooted vegetation, so the remaining species also find little to feed on. As a consequence, wildfowl mainly use the Avon shore as a roost site and a refuge from wildfowling and other forms of disturbance - in contrast with some other parts of the Severn Estuary where the presence of *Zostera* attracts more wildfowl (especially Wigeon and Tufted Duck).

The one species that thrives in these conditions is the Shelduck, and for much of the year it is the most numerous wildfowl on the shore. It feeds by sifting the estuary mud at low tide to extract common invertebrates (*Hydrobia* being the main prey). Early in the year usually about 500 birds (some 20% of the Severn Estuary population at this time) are present between Brean Down and Oldbury. Only a small percentage of these birds breed and they normally produce fewer than 100 young. Many pairs apparently in breeding condition do not breed; lack of suitable nest sites may be one cause. Most birds leave the area to moult. Their departure starts in late May or early June, when non-breeders begin to move up the Estuary; by mid-July most have moved to the Heligoland Bight, off the German North Sea coast, to moult. (The majority of the birds moulting in Bridgewater Bay are thought to be of Irish origin.) There is a slow build up in numbers in the Estuary from September onwards as birds return after the moult. These movements are illustrated in Figure 1, using counts made over ten years between Clevedon and Woodspring Bay; they are typical of the Avon shore as a whole.

Mallard, Teal and Wigeon are the only commonly occurring dabbling duck species and no diving duck occurs regularly along the Avon shore. Mallard are present throughout the year and the species breeds near ponds and on quiet rhines behind the sea walls, as well as further inland. Apart from the usual ground nesting, some pairs nest in pollarded willows, up to three metres above ground, to avoid predation. No detailed survey has been undertaken but it is unlikely that more than 100 pairs breed successfully along the whole coast in any one year. From late summer to early spring Mallard are commonly seen on the shore or swimming just off it. In a typical winter some 1,000 birds are present along the coast, with concentrations at New Passage, in the Royal Portbury Dock and in Sand Bay. Numbers can increase markedly in cold weather if the reservoirs in south Avon and

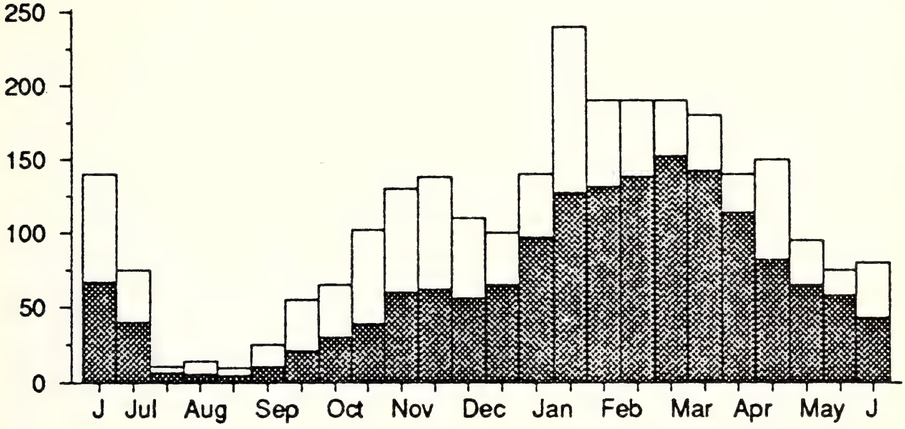

FIGURE 1. Average (shaded) and maximum (unshaded) counts of adult Shelduck between Clevedon and Woodspring Bay, taken fortnightly from June 1980 to June 1990.

north Somerset freeze over. Both Teal and Wigeon occur mainly from October to mid-February and their patterns of occurrence and numbers are similar to those of wintering Mallard. Cold weather does not seem to affect Teal greatly, but has produced some notable Wigeon flocks; for example, during the cold spell in January 1987 more than 7,000 were recorded off New Passage.

Many duck, as well as goose and swan, species have been recorded on or near the Avon coast, but generally in low numbers and only occasionally. Most are seen when cold weather displaces them from the frozen reservoirs inland. Cold spells in late winter are not so productive; it is conjectured that at this time the displaced birds prefer to move south to the English Channel. The main species involved in these movements are White-fronted and Brent Geese, Pintail, Shoveler, Tufted Duck and Pochard. Recently Eider and Common Scoter have been more numerous, the latter often in midsummer. The main reason for this poor wildfowl showing in the near Estuary and along the shore must surely be the turbidity of the water, and its lack of vegetation and suitable food items. There is some wildfowl shooting in a few areas, notably south of Clevedon; this must reduce numbers and, through disturbance, affect sightings. Also in some areas, notably the Axe Estuary, sailing and other leisure activities have a detrimental effect on the water birds.

WADERS

Wading birds provide the main ornithological interest along the Avon shore, and for one species - the Dunlin - it is of international importance; the extensive mud flats and areas of shingle and sand present a wide range of feeding opportunities, and some quiet parts on the sea walls provide good roosts at high tide. At least 35 wader species have been recorded, eleven of which are commonly present in good numbers while a further ten occur regularly. Figure 2 indicates the number of *species* occurring in each fortnightly period of the year. It refers to the shore between Clevedon and Woodspring Bay but is typical of the whole coast.

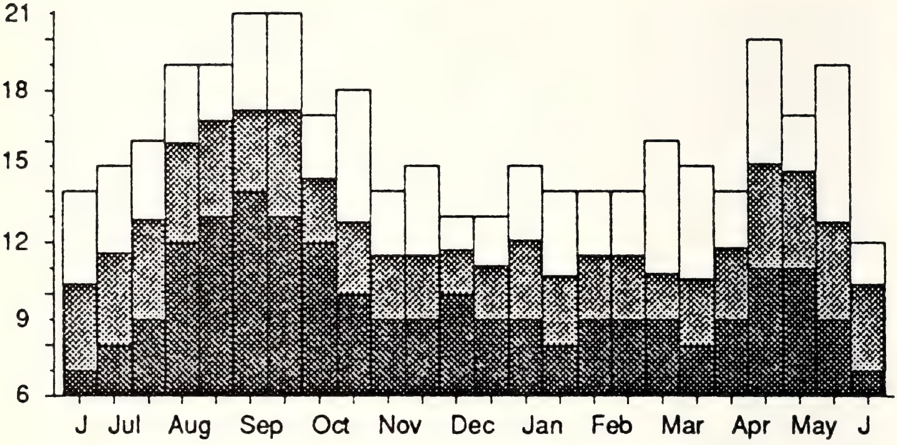

FIGURE 2. Minimum (darker shading), average (lighter shading) and maximum (unshaded) numbers of wader species seen between Clevedon and Woodspring Bay, June 1980 to June 1990.

DUNLIN

The Dunlin is the most important bird species occurring in the Severn Estuary and along the Avon coast. Two quite separate populations are represented. The main one consists of birds from the race *alpina* which breeds in the northern parts of Fenno-scandia and Russia. Most flocks arrive in late October and stay until the end of February, with some movement in a south-westerly direction between sites along the shore in November and a reverse movement in February; exact dates of arrival and of these movements depend on the weather and on feeding conditions. Mid-winter counts along the Avon shore, from Oldbury to Brean Down, range between 6,000 and 30,000, and this higher figure represents about 2% of the world population. (The total Severn Estuary winter population usually reaches 50,000 or more by mid-winter.) Numbers drop during gales or if the mud flats are frozen; coastal fields are used for roosting and feeding if they are wet or partly flooded by shallow pools. Numbers also depend on the state of the mud. Dunlin feed on the invertebrates in the top 'sloppy' mud layer and they have to move elsewhere if this layer is missing or if it becomes very thick (when the prey organisms either burrow down out of reach of the birds or die through lack of oxygen). For instance, in the early part of 1990 storms removed much of this top layer over large stretches of the shore, and in the following winter some counts in these areas were down by 90%. Like many other waders, Dunlin regularly roost in particular sites, and may travel a considerable distance to reach one. Recently a very large roost has developed south of Clevedon, which on at least one occasion has held 16,500 birds; if the birds are disturbed or their favoured spot is covered by the tide, a large 'aerial' roost forms which may last for several hours. Many of the birds roosting here feed on the Welsh side of the Estuary at low water; they arrive to roost in small groups but often depart in a sudden massive exodus, a quite remarkable sight.

The second Dunlin population occurs on spring and autumn migration and comes from the race *schinzii* which breeds in northern Britain, Iceland and southern

Norway, with a few from the race *arctica* breeding in the high arctic and usually noted only in late May. Numbers at given sites are usually under 1,000, but the total passing through the Estuary is not known exactly. An extensive catching and marking scheme would be needed to ascertain the average daily turnover; however, assuming that feeding migrants stay for about ten days and do not move far along the shore, then the average passage would exceed 5,000 birds in most years.

OTHER COMMONLY OCCURRING WADERS

Unlike the species discussed above, both Lapwing and Redshank breed on or near the shore, though in smaller numbers than formerly. For Lapwing, if we restrict attention to sites on or within 1km of the coast, the most important areas are near Portbury and south of Clevedon. In the last ten years each has held from three to twenty breeding pairs, with a noticeable drop during the period. Breeding of Redshank in the county is now virtually restricted to the area south of Clevedon, usually in the fields used by the Lapwing and with an average of ten pairs per year during the decade. Outside the breeding season numbers of both species along the Avon coast range between 500 and 1,500 under normal conditions; Redshank are very faithful to particular sites but Lapwing roam widely both along the shore and inland. At the onset of a severe cold spell large numbers of Lapwing can be seen moving from inland sites to warmer areas in the south-west, with a similar return movement when the weather abates. However, in the Severn Estuary Redshank do not seem to be greatly affected by cold weather and usually leave the mudflats only in extreme cold or during gales. It is possible that some die in cold spells, to be replaced by others moving west (on the east coast of Britain considerable mortality is known to accompany cold spells).

Oystercatcher, Ringed and Little Ringed Plover are the only other wader species breeding along the Avon shore, but never more than three to five pairs breed in any year and the success rate is low. The Oystercatcher is a very common species on most British estuaries but not on the Severn, where large crustaceans (cockles, mussels, etc.) have a very restricted distribution. Quite good numbers of these birds occur on the outer Estuary, at Steart or Burry Inlet for example, but along the Avon shore counts in excess of 25 are uncommon except near the mouth of the Axe and sometimes in Sand Bay. Large numbers of Ringed Plover migrate through the Estuary - in late August 1,500 or more have sometimes been counted along the shore; also a few are present in winter. In some years quite large flocks are also noted during late May and the first week of June; they appear so late in spring because their nesting grounds in north-east Greenland and the high Canadian arctic are frozen until mid-June.

Grey Plover, Snipe, Curlew and Turnstone are common on the shore outside the breeding season; at some sites a few also spend the summer here. Grey Plover are most common south of Clevedon, where up to 100 may occur. The largest Snipe flocks are seen in mid-winter; in cold conditions up to 150 can occur at some sites (e.g. in and around the Royal Portbury Dock) but in mild winters many do not move this far west from their main areas in northern Europe. Curlew are common along the shore for most of the year; the largest flocks occur at Oldbury, where evening roosts of over 1,400 birds have been noted. The main site for Turnstone is Severnside, where up to 400 can occur; they find good feeding conditions on the English Stones at low tide. Last in this main group of wading birds seen along the shore are Whimbrel and Bar-tailed Godwit. Whimbrel occur mainly in spring, when flocks of up to 200 have been recorded south of Clevedon (and even larger flocks further west near the Parrett Estuary); the autumn passage is much smaller, and flocks of 20 are exceptional. In most years fewer than 50 Bar-tailed Godwits are seen at any one time, and these are mostly on spring passage; this is surprising for, like the Oystercatcher, they are common on most British estuaries, especially in winter. However, in a few springs (recently those of 1984 and 1990) the situation is quite different: large flocks of birds in full breeding plumage are seen moving up the Estuary, and some roost on the shore; in 1984 over 5,000 were reported. These occurrences are associated with the same weather conditions as those discussed above for the exceptional tern movements through the Estuary, and in 1990 the terns and godwits appeared together.

THE LESS COMMON WADERS

As noted above, there is a further group of ten wader species which occur every year in numbers mainly ranging between ten and 100, although individual counts are usually much lower. Golden Plover occur mostly in winter and counts are higher in cold weather, when flocks of 200 or more have been reported. Jack Snipe are also mainly seen in winter but in very small numbers; their habit of sitting tight in rough grass or similar habitat until almost trodden upon makes them difficult to census. Sanderling, Little Stint, Curlew Sandpiper, Greenshank and Common Sandpiper are all mostly passage birds and to see more than twenty at a time is unusual, though Common Sandpipers can be more numerous in early autumn. Curlew Sandpiper numbers are very erratic - in some years virtually none are seen but in others (e.g. 1988) over 100 are recorded. Finally in this group we should mention Knot, Black-tailed Godwit and Green Sandpiper. These may be seen at any time of the year, although not usually in May or June. Knot numbers are particularly erratic; although this is a common British estuarine species, counts on the Avon coast are generally low (exceptionally in the 1960s up to 5,000 were sometimes recorded in Sand and Weston Bays). Black-tailed Godwits are strictly passage birds in small numbers; a few Green Sandpipers occur throughout the year outside the breeding season, usually away from the Estuary itself.

LAND BIRDS

This large group includes Grey Heron, the raptors, some game birds, the near-passerines such as Kingfisher and Green Woodpecker, and the passerines, especially some pipits, wagtails, chats, warblers and finches. Not many are associated specifically or only with the shore; most are farmland birds that happen to live close to the coast. For example, Skylark is seen regularly in good numbers, and it breeds, but this is also true for much of Avon's farmland, although the highest densities occur along some parts of the shore. Nevertheless a number of characteristic land birds are recorded more often near the coast than inland. Grey Herons are often noted feeding along the banks of the Severn and the smaller rivers and ponds. Most Avon records of Hen Harrier and Short-eared Owl, and a good percentage of the records of Merlin and Peregrine, come from the coast in winter.

THE PASSERINES

The finches are probably the most abundant of the passerine groups. Linnets are plentiful for much of the year and in autumn flocks of 500 or more may feed close to the sea walls; a few pairs breed in the coastal fields. Chaffinches are also regular and breed; in late October very large flocks (up to 3,000 in a morning) move south or south-west along the shore, although on some occasions the movements are in a north-easterly direction (Sainsbury, 1972). Many other common finches are also seen at this time in smaller numbers. The Rock Pipit is one land species which is almost exclusively coastal; a few are present along the shore throughout the year and a small number breed. Yellow Wagtails and Reed Warblers occur widely in Avon and there are notable concentrations near the coast; e.g. close to the mouth of the River Yeo there is a breeding colony of Reed Warblers, while parties of Yellow Wagtails, sometimes up to 40 strong, are seen here on migration.

Another characteristic bird of the coast is the Wheatear; it does not breed in the area, but several hundred pass along the coast each spring and autumn. It is usually the earliest migrant to appear, often by the middle of March, and usually the latest to disappear, being seen normally up to late October. Stonechats were fairly common ten years ago but now only a few are to be seen, mainly in winter. On the other hand, Whinchats are strictly passage birds on the coast; typically totals are fewer than 50 in spring and 100 or more in autumn. Finally come two exclusively winter species: Twite and Snow Bunting. During the cold winters in the earlier part of the 1980s Twite were seen quite regularly on the coast and flocks of 30 or more were not uncommon, but very appeared during the warmer winters at the end of the decade. Most Avon records of Snow Bunting are coastal; during a typical winter they total about ten, although a notable flock of 56 occurred south of Clevedon in 1968.

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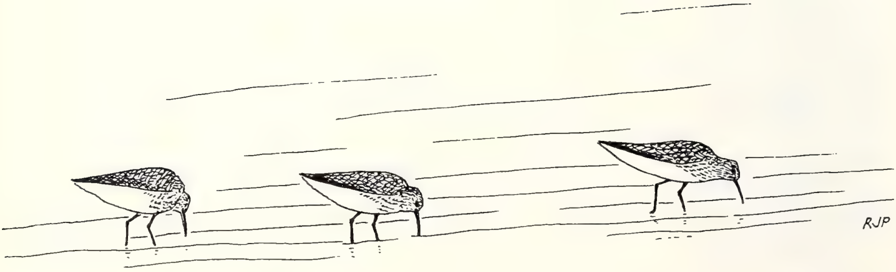

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HEAVY METAL POLLUTION IN THE SEVERN ESTUARY

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INTRODUCTION

Rivers have long been used for the disposal of liquid and semi-solid wastes from domestic and industrial sources, so waters entering estuaries are often highly polluted. An estuary allows opportunity for further dilution and dispersion of the pollutants; indeed some industries have been attracted to estuarine areas because of the capacity to disperse and assimilate pollution wastes. Like other estuaries with large cities, major industries and ports on their margins, the Severn Estuary has a reputation for being relatively heavily contaminated. In part that reputation has come from the presence of certain heavy metals, especially zinc, cadmium and lead, in the water and sediments.

The sources of these heavy metals are various. Metals enter the sewage disposal systems and some are not removed by the treatment processes before disposal of the waste-waters and sewage sludges. Sewage sludge from Bristol has been dumped in the Estuary for many years, an activity which is anticipated to cease by 1993, and the Estuary receives further effluent directly from a number of industrial sewers. Airborne dusts derived from smelting and refining industries and incinerators also contribute to heavy metal input; Owens (1984) suggested that as much as 21·1% of the total cadmium and 42·2% of the total zinc inputs into the Estuary came from atmospheric deposition. Other sources are run-off and land drainage from mineralized areas. The Mendips were the site of very large scale lead and zinc mining and smelting from Roman times up to the nineteenth century (Gough, 1930); streams and rivers draining such areas may become contaminated, to an extent greatly influenced by water acidity. Owens (1984) estimated that anthropogenic sources of heavy metals (i.e. domestic sewage, industrial effluents and airborne deposition) account for 66·2% of cadmium, 33·4% of copper, 68·8% of zinc and 80·8% of lead in the Estuary.

Thus heavy metals in the estuarine waters and sediments have accumulated from many geographical points and sources. The concentrations reached by these metals depend also on the time it takes a particular body of water to escape from the Estuary to the open sea. According to Uncles & Radford (1980) this 'flushing time' in the Severn varies from about 100 days in winter to 200 days in summer (see also Uncles, 1984). These rather long times clearly help to maintain relatively high concentrations of metals in the estuarine ecosystem.

A number of studies have been made of water quality, sediments and biological samples collected from the Estuary. The evidence they provide suggests that the most heavily contaminated areas on the southern side of the Estuary occur in the Portishead and Avonmouth areas. Ecologically the impact of heavy metals in the Estuary is difficult to assess, but the highest concentrations of metals are found in gastropod species and some algal species. The following account concentrates on two habitat types: salt marshes and rocky shores.

SALT MARSHES

Comparison of the present day distribution of vegetation on Severn Estuary salt marshes with the account given by Priestley (1911) shows that major changes in floral composition and distribution have taken place. The most important change has been the invasion by *Spartina* (formerly referred to as *S.* × *townsendii* but the majority is now referable to *S. anglica*; see Martin, 1992). Roper (1918, 1919) recorded the planting of *Spartina* at Clevedon in 1913 in an attempt to control coastal erosion. Roper (1924) recorded the spread of *S. anglica* to Berrow and sites upstream in west Gloucestershire. Further information about the history and spread of *Spartina* along the Estuary shore is given by Martin (1992). The present abundance of *S. anglica* throughout the Estuary is the result of both natural spread and planting regimes. *Spartina* has been most spectacular at preventing mass erosion of mud flats; in Bridgwater Bay, Ranwell (1964) estimated that there had been silt accretion to a depth of 135 cm since 1928. Despite these marked changes since the introduction of *S. anglica*, the stepped profile of a stylized marsh, as illustrated by Priestley (1911), is still found and is the result of accretion versus erosion by tidal scour. Little (1992, fig. 1) gives an example of the salt marsh profile and vegetation zones at Chittening Warth.

The concentrations of heavy metals in the above-ground parts of plants at Chittening Warth salt marsh are very little above those for uncontaminated sites, e.g. cadmium 0·13-1·59 ppm (parts per million), zinc 21-121 ppm, lead 8-51 ppm and copper 4-15 ppm (all on a dry weight basis; data for a range of species collected from different vegetation zones on the salt marsh). The sediments, however, show interesting trends of metal concentrations with depth. Figure 1 shows depth profiles for four metals at a low shore site at Chittening Warth. The site corresponds to the Northwick Surface shown by Little (1992, fig. 1). Profiles from other positions at Chittening Warth, as well as from Northwick Oaze and Littleton, show similar characteristics in that at a particular depth (see 35 cm in Figure 1) a sharp cut-off separates lower sediments, with approximately background concentration of metals, from the clearly contaminated sediments above.

Allen & Rae (1986) noted similar changes in heavy metal profiles at various places in the upper Estuary. They subdivided their sections into a lower 'pre-industrial zone', a middle 'industrial zone' and an upper 'post-industrial zone' based on zinc, copper and lead analyses. They dated the rise in metal concentration in their 'industrial zone' to a period between 1840–1850 and 1940–1950.

In our studies, the sharply defined profiles occur at sites close to the Avonmouth smelting complex, which started smelting lead, zinc and cadmium in 1928 (Cocks & Walters, 1968). At about the same time *S. anglica* invaded the salt marshes in this area and changed the patterns of silt accretion. The coincidence of these two events and the presence of a clearly contaminated upper layer overlying almost contamination-free sediment suggests that the contaminated layers have been deposited since 1928 and coincide with accretion brought about by *S. anglica*. As yet we have no definitive dating of the upper layer, but aerial photographs dated 1946, 1963 and 1984 show changes in the topography of Chittening Warth associated with the dominance of the vegetation by *Spartina*. The depths of sediment with high concentrations of heavy metals are well within the rates of accretion associated with *S. anglica* discussed by Ranwell (1964). Our interpretation of the data would seem to be consistent with the findings of Allen & Rae (1986).

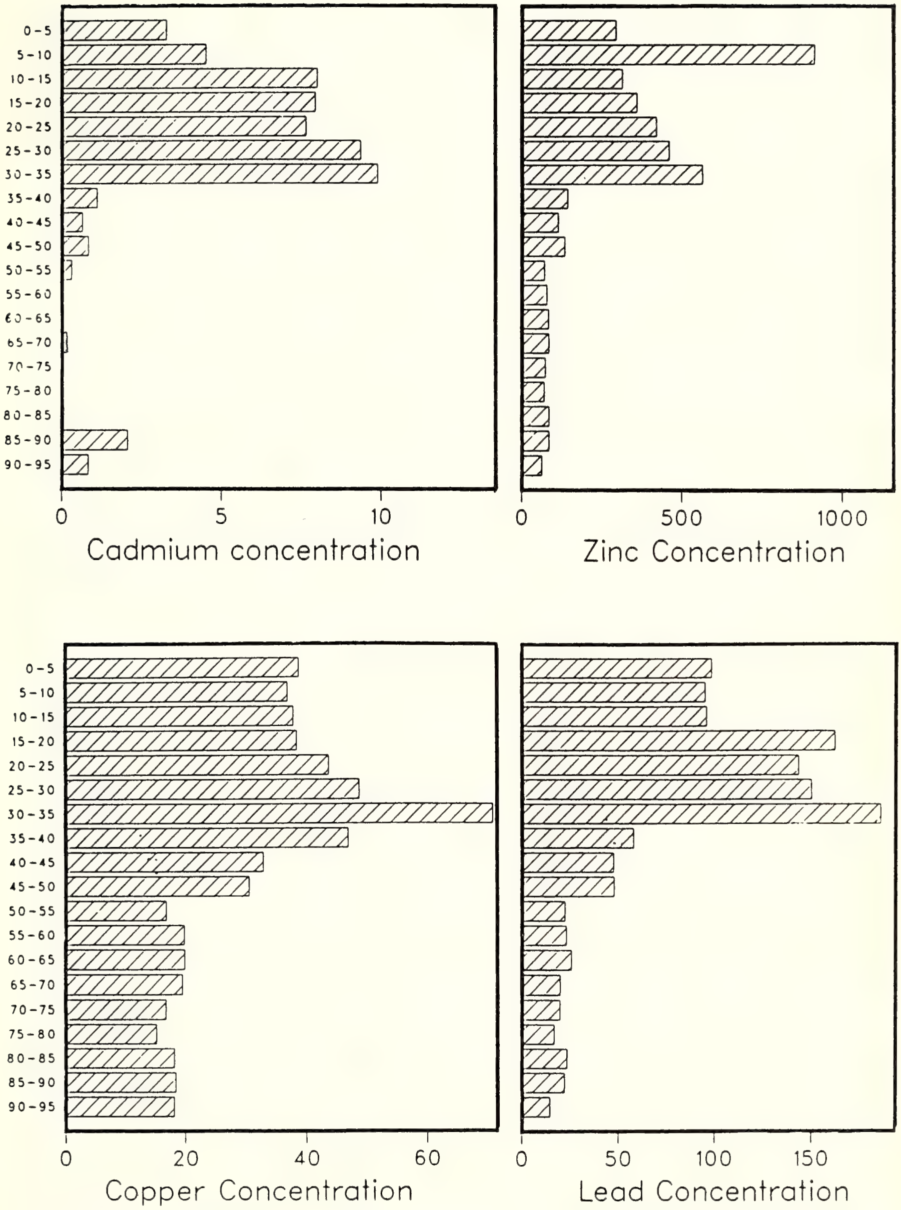

FIGURE 1. Changes in concentrations of cadmium, zinc, copper and lead (ppm) with depth (cm) in a low-shore profile of the sediment at Chittening Warth salt marsh.

ROCKY SHORES

The flora and fauna of the Estuary's rocky shores have been described in many papers (e.g. Bassindale, 1941, 1942, 1943; Purchon, 1938; Smith & Little, 1980). The rocky shores have also attracted attention in connection with heavy metal contamination and its effects on and concentrations in a range of organisms (Butterworth *et al.,* 1972; Nickless *et al.,* 1972; Peden *et al.,* 1973; Fuge & James, 1974; Stenner & Nickless, 1974; Crothers, 1976; Hopkin *et al.,* 1985).

Much of the interest focuses on the extremely high concentrations of metals, particularly the highly toxic cadmium, which have been recorded in the gastropods *Patella vulgata* (limpet) and *Nucella lapillus* (dog-whelk). Table 1 shows the average and maximum concentration of metals in limpets from twelve monthly samples (1984-1985), for Sand Point and Portishead. Also given are the mean values for limpets collected from five sites in Orkney in 1985. The limpets from the Severn Estuary are on average nineteen times more polluted with cadmium than those from Orkney. For zinc, copper and lead the values are five, four and seven times respectively.

TABLE 1. Concentrations of heavy metals (as ppm dry weight) in the soft parts of limpets (*Patella vulgata*) collected from three sites. The Orkney samples, assumed to be unpolluted, were collected from five stations on one occasion for comparison with the two Severn Estuary sites. The Portishead and Sand Point data are means for samples collected over a twelve month period (1984-1985) from the mid-shore region. All samples include individuals of a range of sizes. (n = number of sample measurements in the mean).

Site		*Cadmium*	*Zinc*	*Copper*	*Lead*
Orkney (n=47)	mean	8·4	114·5	13·7	0·7
	max.	50	530	70	16·5
Portishead (n=155)	mean	159	380	28	4·8
	max.	1,080	4,500	1,700	100
Sand Point (n=179)	mean	114	563	55	3·5
	max.	600	1,400	85	87

Dog-whelks, which do not occur above Sand Point, contain even greater concentrations of cadmium and zinc than do limpets. Feeding habits, food material and immersion times are likely to cause these differences (see Table 2).

The above data all refer to the soft parts of these molluscs; the shells contain very low concentrations of the metals concerned. Limpet shells from Sand Point contained on average 0·06 ppm cadmium, 2·35 ppm zinc, 0·01 ppm copper and 0·3 ppm lead. Data for shells of other mollusc species were very similar.

Figure 2 shows the heavy metal concentrations in a range of organisms collected from Sand Bay in the period 1984-1985. The greatest step in accumulation of these metals along the food chain appears to be taken by the algae. Concentration factors, i.e. concentrations in seaweeds relative to concentrations in sea water, show very high values (see Table 3), particularly for zinc. Amongst the

TABLE 2. Mean concentrations of heavy metals (as ppm dry weight) in the soft parts of dog whelks (*Nucella lapillus*) from Sand Point. Samples were collected monthly over twelve months (1984-1985). Data from Butterworth *et al.* (1972) based on one collection at Brean are included for comparison. (n = number of samples).

Data source	*Cadmium*	*Zinc*	*Lead*
Butterworth *et al.* (1972) Brean (n=minimum 6)	725	3,100	27
Beckett (1986) Sand Point (n=53)	322	4,149	3·2

TABLE 3. Concentration Factors (organism concentration/food concentration) for a range of organisms at Sand Point. The data for brown algae are the averages for five species.

Organism	*Food/substrate*	*Cadmium*	*Zinc*	*Lead*
brown algae	sea water++	4,593	12,563	171
Ascophyllum nodosum	sea water++	3,732	15,882	50
Gloop+	sea water++	2,696	45,420	6,178
Patella vulgata	Gloop+	43	0·4	0·4
Littorina obtusata	*Ascophyllum*	25·3	1·1	1·0
Nucella lapillus	barnacles	35·1	4·5	3·1

+ Gloop is the surface slime on rocks, composed of algal cells, sediment, etc.
++ Using sea water concentrations for Portishead, mean data from Owens (1984), i.e. cadmium 1·38 parts per billion, zinc 19 ppb, lead 1·8 ppb.

animal species the highest concentration factors are for cadmium; those for lead and zinc are much lower. Zinc is an essential element, whilst living organisms do not require lead or cadmium. Cadmium accumulates in animals with time, so that the oldest individuals have the highest concentrations. In the case of zinc, however, there appears to be some regulation of intake because the highest concentrations are usually associated with the smallest (youngest) individuals.

CONCLUDING REMARKS

In biological samples from the Severn Estuary the greatest degree of metal pollution relative to unpolluted samples appears to be from cadmium. Although the concentration of cadmium in sea water is very low, many organisms accumulate it to very high concentrations. The occurrence of such high levels of a toxic

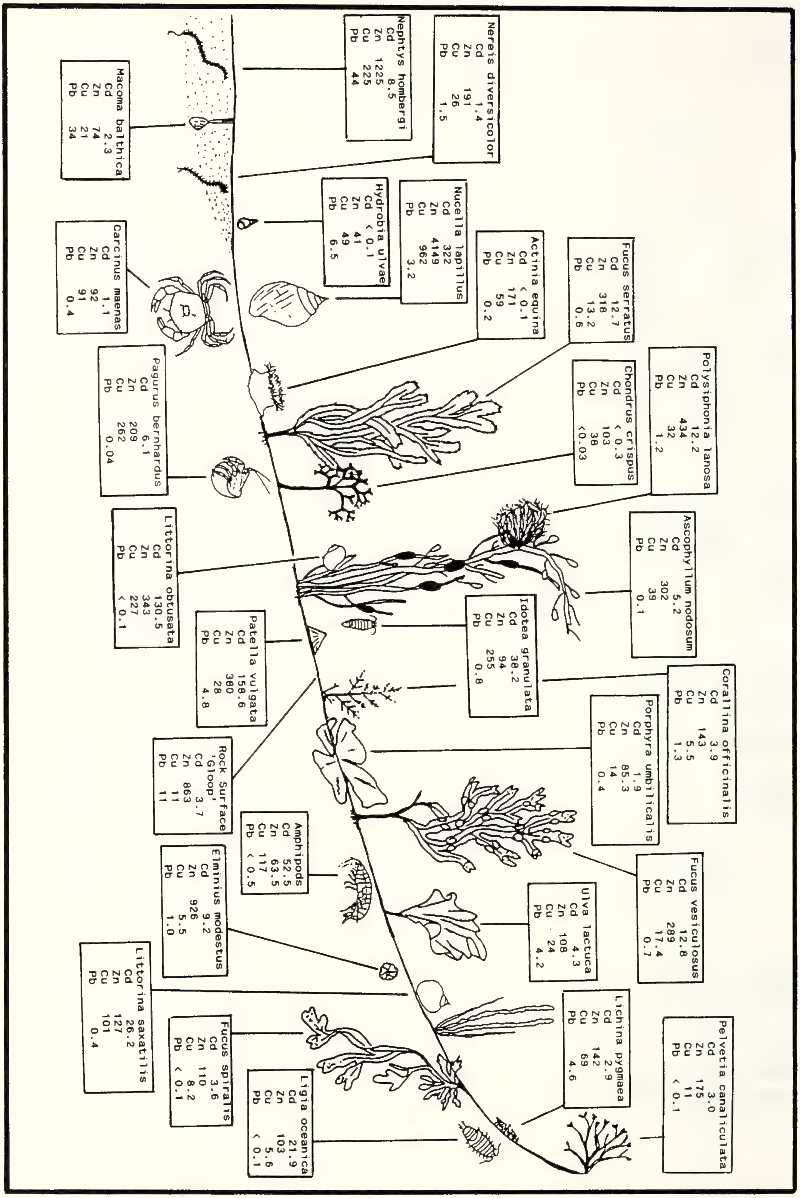
Nereis diversicolor Cd 1.4 Zn 191 Cu 26 Pb 1.5
Nephtys hombergi Cd 8.5 Zn 1225 Cu 225 Pb 44
Macoma balthica Cd 2.3 Zn 74 Cu 21 Pb 34
Nucella lapillus Cd 322 Zn 4149 Cu 962 Pb 3.2
Hydrobia ulvae Cd < 0.1 Zn 41 Cu 49 Pb 6.5
Fucus serratus Cd 12.7 Zn 318 Cu 13.2 Pb 0.6
Actinia equina Cd < 0.1 Zn 171 Cu 59 Pb 0.2
Carcinus maenas Cd 1.1 Zn 92 Cu 91 Pb 0.4
Polysiphonia lanosa Cd 12.2 Zn 434 Cu 32 Pb 1.2
Chondrus crispus Cd < 0.3 Zn 103 Cu 38 Pb <0.03
Pagurus bernhardus Cd 6.1 Zn 209 Cu 262 Pb 0.04
Ascophyllum nodosum Cd 5.2 Zn 302 Cu 39 Pb 0.1
Littorina obtusata Cd 130.5 Zn 343 Cu 227 Pb < 0.1
Idotea granulata Cd 38.2 Zn 94 Cu 255 Pb 0.8
Patella vulgata Cd 158.6 Zn 380 Cu 28 Pb 4.8
Corallina officinalis Cd 3.9 Zn 143 Cu 5.5 Pb 1.3
Porphyra umbilicalis Cd 1.9 Zn 85.3 Cu 14 Pb 0.4
Rock Surface 'Gloop' Cd 3.7 Zn 863 Cu 11 Pb 11
Amphipods Cd 52.5 Zn 63.5 Cu 117 Pb < 0.5
Fucus vesiculosus Cd 12.8 Zn 289 Cu 17.4 Pb 0.7
Elminius modestus Cd 9.2 Zn 926 Cu 5.5 Pb 1.0
Ulva lactuca Cd 4.3 Zn 108 Cu 24 Pb 4.2
Littorina saxatilis Cd 26.2 Zn 127 Cu 101 Pb 0.4
Lichina pygmaea Cd 2.9 Zn 142 Cu 69 Pb 4.6
Fucus spiralis Cd 3.6 Zn 110 Cu 8.2 Pb < 0.1
Ligia oceanica Cd 21.9 Zn 103 Cu 5.6 Pb < 0.1
Pelvetia canaliculata Cd 3.0 Zn 175 Cu 11 Pb < 0.1

FIGURE 2. Concentrations of heavy metals (parts per million, dry weight) in a range of organisms found at Sand Point. Analyses do not include shells of mollusc species. Organisms are not drawn to scale, and relative positions on the transect are approximate.

metal could be expected to harm the organisms concerned. In many animals cadmium is concentrated and bound by a specific metal-binding protein (a metallothionein) and it has been suggested that this mechanism may to some extent detoxify the metal within the organism. Noel-Lambot *et al.* (1980) found cadmium-binding metallothioneins in limpets from Portishead. In other invertebrates, e.g woodlice, there appears to be a threshold of metal burden beyond which the animals fail to survive (Hopkin & Martin, 1982). Shore *et al.* (1975) suggested that high cadmium levels in limpets from the Severn Estuary have an adverse effect on the metabolism of glucose. In a hostile environment such as an estuary, however, where many other environmental factors (salinity gradients, exposure, etc.) affect growth and survival, it becomes difficult to identify and attribute specific effects on the organism to one particular pollutant.

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	Hon. Secretary:	Dr P. R. Crowther
	Hon. Treasurer:	V. Dennison
Ornithological	President:	B. M. J. Gray
	Hon. Secretary	R. G. Holmes
	& Treasurer:	R. G. Holmes

Other Members of Council:

G. R. Best
Dr G. Jones
Miss A. Heckels
Mrs H. Titchen
Dr H. E. Rose
D. P. C. Trump
Dr N. Malcolm
D. A. Wilson

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CONTENTS

GENERAL & SECTIONAL PROCEEDINGS

Council, 1992 2
Report of Council, 1992 4
General Meetings, 1992 5
General Field Meetings, 1992 5
Report of the Botanical Section, 1992 6
Report of the Geological Section, 1992 6
Report of the Ornithological Section, 1992 7
Library Report, 1992 8
Past Presidents 9
Statement of Accounts for the year ended 31 December 1992 10
Editorial 12

BRISTOL BIOTA

Avon & District Entomological Report, 1992 13
Avon Mammal Report, 1992 21
Bristol Botany in 1992 25
INSTRUCTIONS TO AUTHORS 36

ORIGINAL PAPERS

Avon Wildlife Trust and its Nature Reserves, by A. Merritt 37
English Nature and its Conservation Work in Avon, by R. Bradford 47

REPORT OF COUNCIL, 1992

Membership at the end of 1992 stood at 606, showing a continuing increase. At the Annual General Meeting on 18 January, Officers and Members of Council were elected, with Mr R. G. Symes as President. Council met eight times during the year. The committees dealing with the Society's library, its *Proceedings* and the programme of field visits met regularly.

There were five general indoor lectures, all held at the Victoria Church Hall, and the specialised Sections held a total of 16 indoor meetings. Members also had the choice of 44 field visits to a wide selection of habitats and venues. At the annual Buffet Supper, held at the Hall of the Church of the Good Shepherd, Mrs M. Hayman was the speaker and a presentation was made to Mr P. J. M. Nethercott in appreciation of his many years' service as Honorary Treasurer of the Society.

The delayed issue of the *Proceedings* for 1990, on the theme of *The Coast of Avon*, was published. Council records the Society's thanks for sponsorship to Avon County Council, Wessex Region of the National Rivers Authority, Wessex Water and Woodspring District Council. West Air Photography of Weston-super-Mare kindly provided the colour photograph used on the cover, and a grant from the Society's Hector Hockey Fund met the cost of publishing Dr Rose's paper. Council had hoped to see publication of the *Proceedings* brought back on schedule by the appearance of the 1991 issue before the end of 1992. Despite great efforts by those concerned, in the end printing problems moved publication into 1993.

Members of Council served on the Severn Estuary Conservation Group and chaired the Management Committees of Leigh Woods (National Trust) and of the Wetmoor woodland Reserve near Wickwar (Gloucestershire Wildlife Trust). Liaison is maintained with the Avon Flora Project and with the Avon Wildlife Trust through our Honorary Conservation Liaison Officer. The Society participated in the Dawn to Dusk event organised by English Nature in and around the Avon Gorge. Also, three walks were organised for Avon County Council's Walking in Avon series.

Council records the Society's grateful thanks to Mrs D. Grenfell for a donation in memory of her late husband, to Miss D. I. Parsley for a legacy, to friends of Miss M. S. E. Plater for a donation in her memory, to Miss M. E. Jervis for books and journals, as well as to other members for donations of books and furniture for the Library, and for donations to the Harry Savory Illustrations Fund, to our Conservation Fund and to assist in running the Society. One use made of the latter was to meet the extra cost of using recycled envelopes for the *Bulletin*. The R. G. Williams Memorial Fund paid for a slide projector for use at meetings.

The Society's small herbarium was presented to the City Museums and Art Gallery, in whose care it can be properly conserved. Council again thanks Bristol City Council's Director of Arts, Mr M. Heighton and Assistant Director of Arts (Museums & Art Gallery), Mrs H. Woolley, for the use of rooms for meetings of the Botanical Section, as well as for the continued accommodation of the Society's Library within the City Museum.

We report with regret the deaths during 1992 of Dr C. F. Gozna, Miss M. E. Jervis, Miss D. I. Parsley, Miss M. S. E. Plater and Dr R. P. Warin.

SYLVIA KELLY, *Hon. Secretary.*

GENERAL & SECTIONAL PROCEEDINGS

GENERAL MEETINGS, 1992

18 Jan. Annual General Meeting & Presidential Address - "Who killed Cock Robin?", by Mr R. G. Symes.

8 Feb. "Wildlife in Venezuela", by Mr S. Garrett.

5 Mar. "Butterfly conservation in forests", by Mr Robin Khan.

8 April Annual Buffet Supper - "Up the garden path", by Mrs M. Hayman.

3 Oct. "Wildlife in Russia", by Mr Nigel Marvin.

5 Nov. "Bat conservation at home and abroad", by Dr G. Jones.

3 Dec. "Iceland - land of ice and fire", by Dr R. Bradshaw.

SYLVIA KELLY, *Hon. Secretary.*

GENERAL FIELD MEETINGS, 1992

28 Mar. Miss R. C. Lee. Betty Dawes Wood and Newent Falconry Centre. Morning: guided tour of Gloucestershire Wildlife Trust's Betty Dawes Wood; wild Daffodils, very prolific, were at their best. Afternoon: guided tour of Newent Falconry Centre with two flying displays.

17 Apr. Miss R. C. Lee. Forest of Dean. Morning walk round Wenchford Forest Trail, with extensive views over the Forest. Afternoon visit to Dean Heritage Museum and walk round Soudley Pools.

16 May Miss R. C. Lee. Wylie Valley, near Warminster. Walk along Long Dean Bottom and up to bluebell wood. Spring flora and butterflies seen; summer migrants heard on a warm and sunny day included Nightingale.

20 Jun. Dr N. Malcolm. Braunton Burrows. The Warden, Mr Breed, showed the party a wonderful selection of plants, including the very rare Sand Toadflax *Linaria arenaria.*

11 Jul. Miss S. Garden. Sirhowy Valley Walk, Gwent. A very wet walk down the valley from Manmoel to Rock. Flowers included large patches of Pearl Everlasting *Anaphalis margaretacea*, Common Cudweed, Pale Flax and Lemon-scented Fern. Bad weather forced cancellation of the planned afternoon visit to Sirhowy Country Park.

12 Sep. Mr D. A. Cullen. A visit to Portland Bill, Ferry Bridge and Radipole lakes to see autumn bird migrants.

24 Oct. Miss S. Garden. Wye Valley. Walk downstream from Bigweir to Brocksweir and then Tintern Railway Station. Excellent autumn colour; good views of Buzzard, and of duck and geese on the river.

21 Nov. Miss R. C. Lee. Forest of Dean. Walk round the "Sculpture Trail" to see the interesting and unusual 'creations' displayed in various parts of the Forest. A few woodland birds also seen on a damp day.

RACHEL C. LEE, *Hon. Secretary, Field Committee.*

REPORT OF THE BOTANICAL SECTION, 1992

At the Annual General Meeting held on 20 January 1992 the following were elected: President - Mr A. C. Titchen; Hon. Secretary & Treasurer - Mr A. G. Smith; Committee - Miss I. F. Gravestock, Mr C. W. Hurfurt, Mr & Mrs M. A. R. Kitchen, Dr N. Malcolm, Mr P. J. M. Nethercott, Miss A. P. Pockson, Mrs A. C. Titchen and Mrs E. Vaughan-Davies.

The following indoor meetings were held:

20 Jan.	Annual General Meeting & Members' Evening.
27 Feb.	"Plants of French high mountains", by Dr M. H. Martin.
26 Mar.	"The Burren and its ecological background", by Mr P. M. Carter.
6 Oct.	Members' evening. Slides and communications.
4 Nov.	"Botany in Crete", by Mr A. C. Titchen.
10 Nov.	"Introduction to wild flower photography", Workshop led by Mr C. Crosbie.
8 Dec.	"The plant ecology of Berrow and the Braunton sand dunes", by Prof. A. J. Willis.

The following field meetings took place, under the leadership of those shown:

8 Mar.	Compton Wood Quarry, Mr P. Martin.
26 Apr.	Edford Wood, Mr D. Thompson.
16 May	Bourton Combe and beyond, Mr P. J. M. Nethercott.
13 Jun.	Leigh Woods, Dr C. Lovatt.
18 Jun.	Blackdown on Mendip, Miss A. P. Pockson.
28 Jun.	Dyffryn Gardens, Miss I. F. Gravestock.
4 Jul.	Wavering Down and King's Wood, Mendip, Mr P. J. M.. Nethercott.
7 Jul.	Ham Green Pool, Pill, Mr M. A. R. Kitchen.
18 Jul.	Harptree Combe, Miss A. P. Pockson.
2 Aug.	Great Breach Wood and Gilling Down, Mrs E. Vaughan-Davies.
5 Sep.	The rhynes at Kingston Seymour, Mr P. J. M. Nethercott.
19 Sep.	Stock Hill Woods, fungus foray, Mr J. Keylock.

A. G. SMITH, *Hon. Secretary.*

REPORT OF THE GEOLOGICAL SECTION, 1992

At the Annual General Meeting held on 19 February the following were elected: President - D. A. Wilson; Hon. Secretary - Dr P. R. Crowther; Hon. Field Secretary - Mr S. Carpenter; Hon. Treasurer - Mr V. D. Dennison; Committee - Dr M. J. Benton, Mr D. Cope, Mrs M. E. Poolman and Dr M. J. Simms.

The following indoor meetings were held:

15 Jan.	"Terrible Reptile! - new light on an armoured dinosaur from south-west England", by Dr David Norman (Bristol City Museum Winter Lecture Series).
19 Feb.	Annual General Meeting & Presidential Address - "The geology and scenery of eastern Almeria, Spain", by Mr D. A. Wilson.
18 Mar.	"The oceanic crust and mantle - what are they made of and how are they formed?", by Dr P. Browning.
21 Oct.	"Writhlington Geological Nature Reserve; a conservation success story", by Dr E. Jarzembowski.
11 Nov.	"Pterosaurs: new views on old fliers", by Dr D. Unwin.
16 Dec.	Members' Evening.

The following field meetings were held, under the leadership of those shown:

26 Apr.	Hock Cliff, Tuffley Brick Pit and Leckhampton Hill, Dr N. Chidlaw.
9 May	Upper Triassic and Lower Jurassic of the Severn Valley, Dr M. J. Simms.
5 Jul.	Landscape interpretation in western Mendip, Mr V. Dennison.
9 Aug.	The clay pit and chalk pit at Westbury, Wiltshire, Mr S. Carpenter and Mr A. Bentley.

PETER R. CROWTHER, *Hon. Secretary.*

REPORT OF THE ORNITHOLOGICAL SECTION, 1992

At the 68th Annual General Meeting held on 22 January the President, Mr B. M. J. Gray thanked Mr S. M. Taylor and Mr R. Ford, who had both retired from the Committee, for their services.

The Section's indoor meetings during 1992 all touched on bird movements in some way, from the complex pattern of goose flyways in North America to the intricate migrations of waders and Sand Martins, and the seasonal movements of Starlings, in our own hemisphere. In spring we met at Clifton College Preparatory School, and in autumn at the United Reformed Church Hall in Redland Park.

22 Jan.	Annual General Meeting and Presidential Address - "The fall and rise of the Sand Martin", by Mr B. M. J. Gray.
12 Feb.	"Island adventures", by Mr J. Eatough.
11 Mar.	"Parental behaviour in Starlings", by Dr I. Cuthill.
9 Oct.	"In search of waders", by Mr J. Reynolds.
11 Nov.	"Geese in the central Canadian arctic", by Dr A. Fox.
11 Dec.	"Spring in Shetland, autumn in Scilly", by Mr D. Cottridge.

Eighteen field meetings were held, covering every month except July. Destinations ranged from Tregaron to Portland and West Sedgemoor to the Andover area, besides sites in and around Bristol.

Fieldwork was largely concerned with the new BTO Pilot Census project, but work also continued on our surveys of Birds in Gardens, Overwintering Warblers, Corn Buntings, Woodpeckers and Woodland Birds.

RICHARD HOLMES, *Hon. Secretary.*

LIBRARY REPORT, 1992

The post of Hon. Librarian has remained vacant. The Committee did receive a welcome offer of help from a qualified librarian, who was able to obtain for us some very useful advice on cataloguing systems for specialist libraries, but she had to withdraw her support from the Library after a short time because of a change in work commitments. Committee members have continued to carry out routine work in the Library and to adapt the methods used so that they are now more straightforward and effective.

The Library opening hours of Wednesdays 1.15 - 1.45 pm and Saturdays 10.15 am - 12 noon have been maintained. During the year 208 visits were made by 32 members, who borrowed 232 items. Visits by Museum and Art Gallery staff totalled 47. This year five books have been purchased. Currently sixteen journals (including reports and other serials) are received on subscription and 47 by exchange. The level of donations to the Library this year has been particularly gratifying. Eighteen books, 29 reports and 87 journal issues have been given, for which we are indebted to Mr P. J. M. Nethercott, Mr D. A. Wilson, Mr R. G. Symes, Mr S. M. Taylor, Mr S. C. Carpenter, Dr H. Gorvett, Mr C. H. Cummins, Dr J. F. W. McOmie, Mr L. Jones, Mrs A. J. Hollowell, the Bournemouth Natural Science Society and the Smithsonian Institution. Four audio tapes of wildlife sounds have also been donated; these represent the start of an initiative to set up a collection of sound recordings and video tapes for members' private use. The draft planning documents and the Society's comments on them, referred to in the Report of Council, are available in the Library for consultation.

We express the Society's gratitude to Mr M. Heighton (Director of Arts, Bristol City Council) and Mrs H. Woolley (Assistant Director of Arts, Museums and Art Gallery) for the continuing use of the Library Room during the year.

ANNE F. HOLLOWELL, *Chairman, Library Committee*

PAST PRESIDENTS

WILLIAM SANDERS	1862
HENRY E. FRIPP	1876
GEORGE FORSTER BURDER	1880
JOHN BEDDOE	1883
Professor WILLIAM RAMSAY	1884
Rev. THOMAS HINCKS	1887
Professor C. LLOYD MORGAN	1890
Professor ADOLPH LEIPNER	1893
Professor SYDNEY YOUNG	1894
S. H. SWAYNE	1897
Professor C. LLOYD MORGAN	1899
ARTHUR B. PROWSE	1901
C. K. RUDGE	1904
JAMES W. WHITE	1907
G. MUNRO SMITH	1910
Miss I. M. ROPER	1913
G. C. GRIFFITHS	1917
ERNEST (later Sir Ernest) H. COOK	1919
H. WOMERSLEY	1922
Professor O. V. DARBISHIRE	1924
JAMES RAFTER	1927
A. L. FLEMMING	1930
J. W. TUTCHER	1931
F. S. WALLIS	1933
Professor O. V. DARBISHIRE	1934
G. E. J. McMURTRIE	1935
Professor MACGREGOR SKENE	1938
H. TETLEY	1942
Sir LEWIS L. FERMOR	1945
F. W. EVENS	1948
H. H. DAVIS	1950
Professor W. F. WHITTARD	1952
J. H. SAVORY	1954
R. BASSINDALE	1956
Miss M. H. ROGERS	1958
F. COLES PHILLIPS	1960
H. H. DAVIS	1962
R. J. G. SAVAGE	1963
A. F. DEVONSHIRE	1965
F. R. STERNE	1966
R. BRADSHAW	1968
S. M. TAYLOR	1970
Mrs A. F. HOLLOWELL	1972
D. H. PEREGRINE	1974
D. HAMILTON	1976
J. F. W. McOMIE	1978
J. W. COWIE	1980
J. G. PRINCE	1982
V. DENNISON	1983
R. M. PAYNE	1985
T. E. THOMPSON	1987
Miss R. C. LEE	1989

STATEMENT OF ACCOUNTS FOR THE YEAR ENDED 31 DECEMBER 1992

Income and Expenditure for the year

1991	Income	*1992*
3872	Members' subscriptions	3877
366	Income tax repayment	358
235	Donations	166
2371	Sales of Proceedings and grants	1999
162	Sales of books and journals	145
425	General field meetings and Supper	247
536	Bank interest	470
	Entomological Section funds return	49
7967		7311
	Expenditure	
1032	Printing and stationery	1050
854	Postage and telephone	790
3703	Proceedings and Bird Report	1977
78	Severn Estuary pamphlets	
171	Library, books	175
	binding	35
301	subscriptions and journals	298
100	fire insurance	125
18	Donations	21
448	Indoor meetings	449
	General field meetings, loss	32
100	Grants to Sections	180
36	Bank charges	79
6841		5211
1126	Surplus on year	2100
7967		7311

Balance Sheet at 31 December 1992

1991			*1992*
5000	Income Bonds (National Savings)		5000
1677	National Savings Bank		1950
693	Cash at bank - current account		564
8579	- interest account		9077
	Prepayment		4
15949			16595
3594	Less creditors (subscriptions in advance 187; Proceedings for 1991, 1459; other, 81)		1907
12355			14688
	Represented by :		
288	Harry Savory Illustrations Fund		290
167	Conservation Appeal		282
6677	Hector Hockey Memorial Fund		6950
630	R.G. Williams Memorial Fund		473
	General Fund at 31 Dec. 1991:	4593	
4593	Add surplus on year	2100	6693
12355			14688

BENEFACTORS' FUNDS

Receipts and Payments during year

Harry Savory Illustrations Fund

1991		1992
283	Fund at 31 December 1991	288
5	Donations during 1992	2
288		290

Conservation Appeal

1991		1992
167	Fund at 31 December 1991	167
	Donations during 1992	115
167		282

Hector Hockey Memorial Fund

1991		1992
6677	Fund at 31 December 1991	6677
	Add year's investment income	573
	Less one grant made	(300)
6677		6950

R.G. Williams Memorial Fund

1991		1992
630	Fund at 31 December 1991	630
	Additions (Miss D. Parsley bequest, £200; Mrs D. Grenfell in memory of Adrian, £100; friends in memory of Miss M. Plater, £60)	360
		990
	Spent (Purchase of Projector)	(517)
630		473

NOTES TO THE ACCOUNTS

(1) No value is placed upon the stocks of periodicals.

(2) These accounts do not record any balances held by sectional treasurers or the Ornithological Section's Special Fund of £706-07

(3) The Hector Hockey Fund is represented by the Income Bonds and National Savings Bank.

P. J. M. NETHERCOTT
Hon. Treasurer, 1992

28 March 1993

T. B. SILCOCKS
Hon. Auditor
23 April 1993

EDITORIAL

It is regretted that after great progress had been made in reducing delays in publication of the *Proceedings,* this volume, which was scheduled to appear in the autumn of 1993, has been delayed by circumstances quite outside the control of the Editor or of Council.

An important role of the *Proceedings* is to record information on the natural history of the area. Some of this is derived from co-operative efforts by members and others, sharing a common interest. Just as the *Avon Bird Report,* now published separately from the *Proceedings*, includes data from national surveys and from co-operative local studies, the Entomological Report below includes some important records from the Avon Moth Group. Likewise the Mammal Report has contributions from the Avon Bat Group as well as from individual bat specialists, both amateur and professional, including a note on Dr G. Jones's continuing studies on Pipistrelles.

The two original papers give interesting and informative insights into the work of the two main nature conservation bodies operating in the county: the Avon Wildlife Trust (representing amateur interests) and English Nature (the statutory authority).

A. Merritt, for long the Conservation Officer of AWT, gives case histories of both rural and urban reserves. He shows how reserve management involves matters as diverse as reducing soil fertility to save a valuable flora from too vigorous invaders, or being suddenly faced with thousands of wind-blown trees, or the design and maintenance of artificial islands as bird breeding sites. He recounts, too, problems ranging from pyromaniac schoolboys and rogue motorcyclists to the drying-out of reedbeds, and allows us to share the difficult choices posed by inadequate resources.

R. Bradford describes the responsibilities and duties of English Nature and shows how these are applied in Avon, not only in the county's two National Nature Reserves and numerous Sites of Special Scientific Interest, but in the county as a whole. He outlines the issues involved in selecting and designating SSSIs. English Nature's activities on the recording of plant and animal life of particular areas or habitats - the necessary foundation for proper conservation policies - and its important work on species protection are described; both offer a role for the amateur. The author deals also with English Nature's input into planning matters, with its new responsibilities in environmental protection, and with grant aid, concluding with speculations on the future.

The reader will find common themes in the two accounts, both in practical matters, such as how best to maintain unimproved grassland, and in the general field of choosing between one course of action and another when resources are limited. We are grateful to the authors for responding to our invitation to prepare these accounts, particularly so in the case of A. Merritt, who was on the point of moving from AWT to a new post.

Dr Peter R. Crowther
Hon. Editor.
July 1994.

Proceedings of the Bristol Naturalists' Society (1992), **52**: 13-20.

AVON & DISTRICT ENTOMOLOGICAL REPORT, 1992

compiled by R. J. BARNETT

Bristol City Museum & Art Gallery, Queen's Road, Bristol BS8 1RL

INTRODUCTION

Lepidoptera recording received a boost in 1992 through the activities of the Avon Butterfly Project and the Avon & District Moth Group, both co-ordinated by the Bristol/Avon Regional Environmental Records Centre (BRERC), part of the Natural History Section of Bristol City Museum & Art Gallery.

A week of butterfly activities in late May organised by the Museum encouraged more sightings of both common and rarer species to be sent in. Unfortunately the results for 1992 highlighted the plight of butterflies in Avon, with no records received of the High Brown, Marsh or Pearl-bordered Fritillaries, and few localities for the Small and Chalkhill Blues. However, the season began promisingly with good weather encouraging the first brood of the Holly Blue and the first major arrival of migrants, such as the Painted Lady, in May. Conditions for immigration remained good and a number of Clouded Yellow butterflies were reported. The poor summer weather later on coincided with a dramatic crash of the second brood of the Holly Blue, in contrast to its very high numbers during the previous three years.

The Avon & District Moth Group held eight meetings across the county from March to September, made possible by the City Museum's purchase of a portable generator for its moth trap, thanks to grant aid provided by English Nature. In all, 69 species of micro-moth and 162 species of larger moth were recorded at these meetings. They included some of national scarcity such as Blomer's Rivulet and the Barred Hook-tip. 1992 was a very good year for migrant species of moth across southern England, and records from Avon included the Gem, Delicate Dark Sword-grass, Pearly Underwing, Bordered Straw, Scarce Bordered Straw, Silver Y, Convolvulus Hawk-moth, Hummingbird Hawk-moth and *Nomophila noctuella*. Slightly further afield in Somerset, Brian Slade captured the first ever British specimen of a species of Pug moth *Eupithecia sinuosaria* (Slade & Agassiz, 1992) and in Gloucestershire, Neil Woodward took the twentieth British example of Dewick's Plusia moth.

Two important events in 1992 were the publication in November of the book *Dragonflies of the Bristol Region* by Simon Randolph and the appearance of Robert Cropper's paper 'A survey of the distribution of Orthoptera and allied insects in South and North Somerset' in *Somerset Archaeology and Natural History*. Both authors are members of the Bristol Naturalists' Society and regular contributors to this Entomological Report.

Dragonflies of the Bristol Region represents many hours of exhaustive field work by the author and also by John Boyd and Jeff Holmes in particular. There are notes and distribution maps for all species found in the vice-counties of West Gloucestershire and North Somerset (which include Avon) and further information on habitats and conservation. Brin Edwards executed the excellent line drawings.

The orthoptera survey is a tribute to the extensive knowledge of Robert Cropper who was responsible for the majority of the records presented. The paper is an extremely interesting and important contribution to our knowledge of an often neglected group of insects. South Avon is included in the area covered and so the records update some of the sightings published previously by another B. N. S. member (Burton, 1981 & 1982).

I am, as always, extremely grateful to Mr A. H. Weeks for not only submitting his butterfly sightings but also for compiling the meteorological summary for 1992. Climatic conditions can have a profound effect upon insect populations and upon our ability to find and record them. I am also grateful to all those who have submitted records to me of insects rare and common. The lists compiled here are necessarily truncated and species of note have been selected in a rather subjective manner. Those whose records have been included are listed below, and I apologise if you have submitted records which do not appear. All records are lodged in BRERC and assist greatly in assessing population fluctuations in all species.

M. Ashman (MA), Avon Moth Group (AMG), M. Bailey (MB), M. Baker (MBk), R. J. Barnett (RJB), D. Bowring (DB), Mrs E. Brunton (EB), D. L. Buckingham (DLB), J. F. Burton (JB), P. J. Chadwick (PJC), Chew Valley Ringing group (CVRG), R. S. Cropper (RSC), E. A. Dean (EAD), S. Holliday (SH), T. Hunt (TH), E. T. Levy (ETL), National Trust Biological Survey (NTBS), A. C. Neville (ACN), D. Newman (DN), A. Pym (AP), T. B. Silcocks (TBS), R. Smith (RS), D. Warden (DW), A. H. Weeks (AHW), D. A. Wilson (DAW), C. Wiltshire (CW), Mrs P. Woodbridge (PW) and N. Woodward (NW).

Finally, I would like to extend the coverage of this report to invertebrates in general in future years; if you make any interesting sightings of molluscs, millipedes or whatever please let me know.

Scientific nomenclature follows the checklists of Agassiz (1987), Bradley *et al.* (1972), Bradley & Fletcher (1979), Fitton *et al.* (1978), Pope (1977), Potts (1964), Roberts (1987) and Smith (1976).

WEATHER SYNOPSIS, 1992

The mean temperature of 10·7°C equalled the average over the preceding ten years, a slight drop in the mean maximum exactly balancing a slight rise in the mean minimum. February to June and November were warmer than average, while January, July to October and December were all cooler - particularly October. The warmest spells were in the second half of May (triggering off some thundery outbreaks), then June after the first week, with the hottest days of the year on the 27th, 28th and 29th (again followed by thunder) and the last three days of July. The strangest anomaly was that November was warmer than October!

1991's dry weather continued in 1992 as far as June, with the exception of April. Over the second half of the year, wet weather was broken by a very dry October and a completely dry latter half of December. The year's rainfall total was 876 mm, 103% of the long-term average. Monthly and seasonal trends are given below (data compiled from a meteorological station at Yatton).

TABLE 1. Monthly and seasonal trends in climate during 1992.

	Monthly differences			*Seasonal differences*	
	Max. T°	*% Rain*	*% Sun*	*Max. T°*	*% Rain*
Dec.	−1·3	29	63		
Jan.	−0·9	42	75		
Feb.	+1·8	57	85	−0·1	40
Mar.	+0·9	76	75		
Apr.	+0·2	144	90		
May	+2·6	87	135	+1·5	100
June	+2·5	60	120		
July	−1·4	138	80		
Aug.	−1·8	225	75	−0·2	141
Sep.	−1·3	107	80		
Oct.	−2·9	52	100		
Nov.	+1·0	202	85	−1·1	117

Notable monthly features are as follows.

January The only snow observed in 1992 fell with rain on 9th (there was no lying snow at any time). There was a cold snap over the last ten days.

June The year's highest temperature was 29·7°C on 29th.

August The 13th was the year's wettest day at this station, with 31·9 mm rain – the only day to exceed 25·4 mm (1 inch).

September Heavy thunderstorms over parts of Avon and Gloucestershire. Bristol recorded 32·8 mm (1·29 inches) on 18th.

December Warm first half, cold second half. No measurable rain after 18th.

SPECIES OF NOTE IN 1992

LEPIDOPTERA (butterflies)

Clouded Yellow *Colias croceus* (Geoffr.) Aust sewage works ST5789 15 May (PJC); near Wapley Common, Yate ST7180 22 May (DN); Battery Point, Portishead ST4677 15 & 16 July (TBS); East Harptree ST5554 & ST5655 18 July (PW); Ashcott Heath ST4439 19 July (RSC); Catcott North meadows ST4041 22 July (RJB); Portishead Down ST47 27 July (DB); Charterhouse ST5056 2 August (RSC); near Dyrham Wood ST7474 6 August (PJC); Middledown Farm ST7574 10 August (PJC); Portishead ST47 14 & 15 August (M. A. Silcocks *per* TBS); Brean Down ST2958 4 October (RSC).

Red Admiral *Vanessa atalanta* (L.) Bitton ST6870 13 December, in flight (SH).

Camberwell Beauty *Nymphalis antiopa* (L.) Claverham ST46 (Mr J. Cagwyn *per* AHW).

Small Pearl-bordered Fritillary *Boloria selene* (D. & S.) Priddy ST55 12 June (CN); Wavering Down ST4255 25 June (KP).

Dark Green Fritillary *Argynnis aglaja* (L.) Wavering Down ST4255 25 June (KP); Cheddar Cliffs ST46 25 June (DB).

Silver-washed Fritillary *A. paphia* (L.) Clevedon Court ST47 18 July (DB).

The Grayling *Hipparchia semele* (L.) Wavering Down ST4255 25 June (KP).

LEPIDOPTERA ('macro'-moths)

Five-spot Burnet *Zygaena trifolii* (Esp.) ssp. *palustrella* Ver. Midger Wood ST7989 31 May (RJB).

Small Eggar *Eriogaster lanestris* (L.) Kingston Seymour ST3867 6 June, larval nest on blackthorn (RSC); Burnham-on-Sea ST3150 9 June, larval nest on blackthorn (RSC); West Huntspill ST2946 26 June, larval nest on hawthorn (RSC).

Light Orange Underwing *Archiearis notha* (Hb.) Wetmoor ST7487 & 7387 8 March, 9 & 18 April (CW).

Oblique Carpet *Orthonama vittata* (Borkh.) Midsomer Norton ST6554 no date (TH).

The Gem *Orthonama obstipata* (Fabr.) Sand Bay ST36 21 August (EAD).

Chalk Carpet *Scotopteryx bipunctaria* (D. & S.) Draycott Sleights ST4851 26 July (DLB); Selsey Common SO8303 9 August (CW); Stinchcombe Hill ST7498 24 August (CW).

Ruddy Carpet *Catarhoe rubidata* (D. & S.) Folly Farm NR ST6060 30 May (RJB).

Eupithecia sinuosaria Eversmann Berrow ST25 13 June (Slade & Agassiz, 1992).

Drab Looper *Minoa murinata* (Scop.) Stinchcombe Hill ST7498 24 June (CW).

Speckled Yellow *Pseudopanthera macularia* (L.) Ashen Plains Wood ST7696 26 May (CW); Stinchcombe Hill ST7498 3 June (CW).

Convolvulus Hawk-moth *Agrius convolvuli* (L.) Cannington ST23 6 September, female roosting on leeks on allotment (MBk); Langford ST46 22 September (Mr Caperton *per* RJB).

Humming-bird Hawk-moth *Macroglossum stellatarum* (L.) Battery Point, Portishead ST4677 17 May (TBS); Nore Point ST47 17 May (M. A. Silcocks *per* TBS); Saltford ST66 2 August (*per* RJB); Hanham ST67 11 August (Mr Lisk *per* RJB).

Wood Tiger *Paresemia plantaginis* (L.) Stinchcombe Hill ST7398 & 7498 26 & 31 May, 3 & 12 June (CW); Saddlewood Roughs ST8089 31 May (RJB).

Scarlet Tiger *Callimorpha dominula* (L.) Stinchcombe Hill ST7398 & 7498 21 & 27 June, 6 July (CW); Westridge Wood ST7595, 7495, 7494 & 7694 6 July (CW); Brackenbury Ditches ST7494 6 July (CW).

Dark Sword-grass *Agrostis ipsilon* (Hufn.) Ashton Court ST5471 31 July (RJB).

Pearly Underwing *Peridroma saucia* (Hb.) Sand Point ST3265 (AMG); Tyning, Timsbury ST6558 no date (MB).

Lunar Yellow Underwing *Noctua orbona* (Hufn.) Westbury-on-Trym ST57 28 July, one male, at light (JB).

The Delicate *Mythimna vitellina* (Hb.) Tyning, Timsbury ST6558 no date (MB).

Shore Wainscot *M litoralis* (Curt.) Sand Bay ST36 21 August (EAD).

Obscure Wainscot *M. obsoleta* (Hb.) Chew Valley Lake ST5658 no date (CVRG).

Brown-veined Wainscot *Archanara dissoluta* (Treit.) Chew Valley Lake ST5658 no date (CVRG).

Silky Wainscot *Chilodes maritimus* (Tausch.) Chew Valley Lake ST5658, larvae, no date (CVRG).

Scarce Bordered Straw *Heliothis armigera* (Hb.) Chew Valley Lake ST5658 31 July (MA).

Bordered Straw *H. peltigera* (D. & S.) Sand Bay ST36 21 August (EAD).

Dewick's Plusia *Macdunnoughia confusa* (Steph.) Wildfowl & Wetlands Trust, Slimbridge SO7204 18 September (NW) - 20th UK record.

LEPIDOPTERA ('micro'-moths)

Semioscopis steinkellneriana (D. & S.) Wetmoor ST7487 27 March (AMG).

Agonopteryx kaekereritziana (L.) Folly Farm NR ST6060 12 July (RS *det.* RJB).

Pancalia leuwenhoekella (L.) Saddlewood Roughs ST8089 23 May (RJB).

Adoxophyes orana (F. v. R.) Silkwood, Westonbirt ST8488 30 May, male in pheromone trap, probable first Gloucestershire record (CW).

Donacaula forficella (Thunb.) Folly Farm NR ST6060 23 July (RS *det.* RJB).

Sitochroa verticalis (L.) Filton ST6179 31 May & 10 June (AP).

Cryptoblabes bistriga (Haw.) Weston Big Wood ST4575 26 June (AMG).

Nomophila noctuella (D. & S.) Bishopston, Bristol ST5875 15 May (RJB); Tyning, Timsbury ST6558 no date (MB); Chew Valley Lake ST5658 no date (CVRG)

Amblyptilia punctidactyla (Haw.) Weston Big Wood ST4575 26 June (AMG).

EPHEMEROPTERA (mayflies)

Ephemera danica Mull. River Chew, Coley ST5855 16 February, nymph (RSC).

Ephemerella ignita (Poda) Edford Wood ST6648 23 February, nymph (RSC)

Cloeon simile Eaton Blake's Pools, Yeo estuary ST3666 30 August, nymph (RSC).

Ecdyonurus dispar (Curt.) Edford Wood ST6648 23 February, many nymphs (RSC).

E. torrentis Kimmins Edford Wood ST6648 23 February, many nymphs (RSC).

ODONATA (dragonflies)

Beautiful Demoiselle *Calopteryx virgo* (L.) Chew Valley Lake (Wick Green) ST55 29 May (DW).

Common Hawker *Aeshna juncea* (L.) Orchardleigh Lake ST7850 27 September, several (RSC)

Ruddy Darter *Sympetrum sanguineum* (Mull.) Chew Valley Lake (Villice) ST55 29 August (DW).

ORTHOPTERA (grasshoppers and crickets)

Great Green Bush-cricket *Tettigonia viridissima* L. Catcott Heath ST4040 & ST4041 14 August, many singing (RSC).

Large Marsh Grasshopper *Stethophyma grossum* (L.) At its Somerset Levels site ST44 14 August, at least ten individuals (RSC).

HEMIPTERA (true bugs)

Juniper Shieldbug *Elasmosethus tristriatus* (Fabr.) Redland, Bristol ST5775 28 September, third Avon record (EB); Ashton Court ST5471 11 November (RJB).

Zicrona caerulea (L.) Old Down ST6186 13 May (RJB).

Gorse Shieldbug *Piezodorus lituratus* (Fabr.) West Hay Moor NR ST4543 29 August (RSC).

Acompocoris pygmaeus (Fall.) Stock Hill Plantation, Priddy ST5551 8 August, one from pine (RSC).

Saldula orthochila (Fieb.) Stock Hill Plantation, Priddy ST5551 8 August, bare ground on ride (RSC).

Corixa dentipes (Thom.) Orchardleigh Lake ST7850 27 September, two males (RSC).

Corixa affinis Leach Blake's Pools, R Yeo Estuary ST3666 30 August, one female (RSC).

Issus coleoptratus (Fabr.) Leigh Woods NNR ST5573 29 July (RJB).

NEUROPTERA (lacewings etc.)

Osmylus fulvicephalus (Scop.) Midger Wood NR ST7989 31 May (RJB).

DIPTERA (flies)

Ptychoptera longicauda (Tonn.) Prior Park, Bath ST7663 no date (NTBS).

Oxycera morrisii Curt. Prior Park, Bath ST7663 no date (NTBS).

O. pardalina Meig. Prior Park, Bath ST7663 no date (NTBS).

Vanoyia tenuicornis (Macq.) Prior Park, Bath ST7663 no date (NTBS).

Tabanus autumnalis L. near Yatton ST46 4 June (DAW *det.* RJB).

Epistrophe grossulariae (Meig.) Combe Dingle, Bristol ST5577 20 June (ETL).

Volucella inflata (Fabr.) Midger Wood NR ST8089 31 May (RJB).

Xylota tarda Meig. Folly Wood, Folly Farm NR ST6060 21 August, at light (RJB).

HYMENOPTERA (bees, wasps and ants)

Giant Horntail or Wood Wasp *Urocerus gigas* (L.) Ashton Vale, Bristol ST5671 25 August (*per* RJB).

Mellinus arvensis (L.) Burnham-on-Sea ST3050 28 September, large colony in garden (RSC).

COLEOPTERA (beetles)

Hydaticus seminiger (Deg.) Coleford ST6848 5 April, one from pool, first Somerset record since 1949 (RSC).

Hydrochara caraboides (L.) Tealham Moor ST4145 3 October, one in rhyne (RSC).

Hydrophilus piceus (L.) Tealham Moor ST4145 3 October, nine in rhyne (RSC).

Carcinops pumilio (Erich.) Berrow dunes ST2952 29 July (RSC).

Amphimallon solstitialis (L.) Crook Peak ST3955 15 July, numbers flying around trees at dusk (RSC).

Riolus subviolaceus (Mull.) Edford Wood NR ST6648 23 February, three from stream (RSC).

Chrysolina menthastri (Suff.) Catcott Heath ST4041 22 July (RJB); Orchardleigh Lake ST7850 27 September (RSC).

Anthribus resinosus (Scop.) Prior Park, Bath ST7663 no date (NTBS).

ARACHNIDA (spiders)

Scytodes thoracica Lat. Filton ST6179 27 July (AP).

Segestria florentina (Rossi) Clifton ST5873 common all year (RJB *et al.*).

Dolomedes fimbriata (Cl.) Catcott Heath ST4041 22 July, immature (RJB).

Araneus marmoreus Cl. var. *pyramideus* Cl. Nailsea ST4669 11 October (Mrs Beardsley *per & det.* RJB).

Black Widow *Latrodectus* sp. Avonmouth Docks ST57 21 September, female and seven egg sacs (Mr N. Khan *per & det.* RJB).

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AVON MAMMAL REPORT, 1992

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INTRODUCTION

This is the fourth recent Mammal Report for Avon. As before, its purpose is to serve as a register of the interest in the study of wild mammals in Avon.

REPORTS ON MAMMALS

INSECTIVORA (hedgehogs, moles and shrews)

Hedgehog *Erinaceus europaeus*. The Mammal Society Hedgehog Road Kill Survey continued in 1992.

CHIROPTERA (bats)

The National Bat Habitat Survey continued in 1992, the work being undertaken by Allyson Walsh and others at the University of Bristol.

The Avon Bat Group, with financial assistance from South-West Electricity, have erected 73 bat boxes in six small copses around Bristol Water's Chew Valley and Blagdon Lakes. To date, no bats have used the boxes but on 17 May three were being used as nest boxes by blue tits.

Bat records for Avon in 1992 have been compiled by Dr Gareth Jones, Department of Zoology, University of Bristol. Records are from Gareth Jones unless stated. Other observers were David Clark (DC), Robert Cropper (RC), Diana Desmond (DD), Robert Howard (RH), A. F. Jayne (AFJ), Tony Sladden (TS), David Trump (DPCT), Avon Bat Group (ABG), Simon Christian (SC), Graham Best (GB).

Rhinolophidae (horseshoe bats)

Greater horseshoe bat *Rhinolophus ferrumequinum*. Maximum count of 16 at traditional spring "feeding up" site (20 May, DD/JJ). There are two known nursery sites in Avon. One in the south-east of the county contained a maximum of 207 adults, with 77 babies born - an increase over 1991. The other site is in a converted stable block and nearby mines. For the second year running, large numbers returned to the stable block, after deserting the site during renovations. A count of 47 adults in June was typical of counts five years ago, before the renovation. Sixty bats left the stable on 26 July. The maximum summer count of 68 in the nearby mines was lower than in 1991 because of the move back to the stable block. Only about twelve babies were born in the mines in summer 1992. During February, 28 hibernating bats were counted in the mines (DC), and 24 were recorded hibernating in mines in the north-west of the county. A count of 182 in stone mines in south-west Avon during January was encouraging. A radio-tracking study, performed by P. L. Duvergé and G. Jones and funded by the Vincent Wildlife Trust, continues. The colony in south-east Avon was watched almost nightly by TS, whose reports included: one dying in flight on 19 May, soon after leaving the roost; several taken outside the roost in early June by a sparrowhawk; and a tawny owl frequenting the roost area at about the same time. A few bats were still flying around the roost in December. A female hibernating in Dundry was in her 29th year (RC).

Lesser horseshoe bat *Rhinolophus hipposideros.* Up to 23 in north-west hibernacula, and 56 in southern mines. Up to nine hibernating in tunnels under Barrow Hospital ST5638 in January and February, and accumulations of droppings here suggested that the site may be a nursery. Nursery in south-east, on Avon-Wiltshire border, contained up to 24 adults and seven babies (TS). Two in a mine in ST5270 on 15 November and one at Abbots Pool on 6 October.

Vespertilionidae (vespertilionid bats)

Whiskered bat *Myotis mystacinus.* Male, ST4664, 11 May. Female, ST6658, 16 September.

Whiskered/Brandt's bat *Myotis mystacinus/brandti.* In Bath area, one hibernating, ST7662, in January and female found in block of flats, ST7465, also in January died four weeks later. Female found dead inside wood-burning stove in a house in Winterbourne Down ST6579 in August.

Daubenton's bat *Myotis daubentoni.* The first roosts in Avon suggestive of nurseries were discovered: one in ST6868, and one in a tree in the extreme south-east of the county on the Wiltshire border, which contained up to 47 bats, with a maximum of 22 before babies were born (TS). A tree roost at Abbots Pool ST5373 contained up to two bats in spring. Other records from ST6968 on 14 March (AFJ), ST5561 on 18 July ((DD, AFJ, DT), and a bat roosting under a bridge arch on the River Avon at Keynsham, ST6568 on 18 August (AFJ).

Natterer's bat *Myotis nattereri.* A single record of a bat in a roof at Chewton, ST6465, 12-16 April (RH).

Serotine *Eptesicus serotinus.* The nursery roost at Blagdon, ST4959, was still occupied, with 79 counted out by the owner. A further nursery roost at Banwell, ST4058, contained about 20 adults with some young on 23 June. A large roost tree in Bath with *c.*100 bats was saved after tree surgery undertaken in accordance with English Nature advice (SC). Sighting/detector records of single individuals in ST4673 and ST4766. Up to four in south-east of county (TS). One in a roof at Chewton, ST6465, 8-10 March (RH). Bat detector record in ST5373, 10 June (ABG). Female found injured on footpath in Weston, Bath (ST7366) on 16 June gave birth that evening. The baby was rejected and died (AFJ/DD).

Leisler's bat *Nyctalus leisleri.* The usual record from Clifton, Bristol (ST5774); a juvenile female found in a weak state died later in captivity (AFJ/DD). One flying at Abbots Pool, ST5373, 6 May.

Noctule *Nyctalus noctula.* Large numbers continue to frequent Eastville Lake, ST6175. Sightings from ST4565 and ST5370. Colonies at Shirehampton Golf Course, Bristol (20-30 bats: DC) and up to 27 in a tree in the extreme south-east of the county on the Wiltshire boundary; this roost was occupied until 21 June, when Daubenton's bats took it over (TS). Detector record at Abbot's Pool, ST5373 on 10 June (ABG). At Willsbridge, ST6179, 29 counted out of an oak tree roost on 14 May (AFJ). One found in an office canteen died shortly afterwards (AFJ). The year's survival story must be that of "Bootsey", found with a crushed wing in a log pile in Upper Swainswick, ST7568, on 17 October. She "died" after amputation of the wing and was left in the boot of the vet's car. Ten days later she was found alive, well (and hungry!) and now resides permanently at Victoria Street.

Brown long-eared bat *Plecotus auritus.* Hibernating bats at Banwell, ST4059 on 18 January and Wookey Hole, ST5146, in April. Other records from Halford's Superstore, Brislington, Bristol, ST6270; Horfield Prison, Bristol, ST5865, 10 October (AFJ); near Englishcombe, ST7163, 24 April (AFJ); Horfield, ST6077, 13 May (AFJ); Clutton, ST6359, 20 June (AFJ); Leyhill Prison, ST6992, 10 July (AFJ); Keynsham, ST6568, 23 July (AFJ/DD); Newton St Loe, ST7064, 8 August (AFJ); Redwood Lodge, Ashton Court, Bristol, ST5371, 7 August (AFJ); Queen Charlton, ST6367, 12 August (AFJ/DD) and Thornbury, ST6390, 9 September (GB). A bat found in a box discarded by children being chased by a gamekeeper in Burnet, ST6665 in October was taken into care and hibernated successfully (AFJ/DD). The usual colony in roof at Chewton, ST6465, April - November (RH).

Pipistrelle *Pipistrellus pipistrellus.* Work by GJ suggests that there are at least two echolocating "types" of European pipistrelles. Each roost consists of only one type, echolocating with a frequency of most intense emission either close to 46 kHz (I) or close to 55 kHz (II). Roosts investigated were: Aust Church ST5789, *c.*50, 24 June (I); Iford, ST8260, 30 June (II); Wick, ST7072, 9+, late June (I); Ubley, ST5258, 978, 7 July (II); Blagdon, ST5058, 63, 16 July (II); Barrow Hospital, ST5468, 295, 22 July (II). A project is currently investigating whether these "types" are sibling species or whether they are morphs of the same species. The Ubley roost is the largest recorded in Avon to date. Other important pipistrelle roosts recorded were at Butcombe, ST5161, 200+, 18 June (AFJ); Hanham ST6472, 32, 4 June (AFJ/DD); Nailsea, ST4669, 110, 22 June (DT). Smaller roosts were found in ST5663 (AFJ), ST6465 (RH), ST6458 (AFJ), ST5478 (AFJ) and ST6064 (AFJ).

Other records included three hibernating behind a window frame at Dundry, ST5766 in January, of which two were females and were type II; a baby at Stapleton, ST6177 on 30 June; pipistrelles were reported to be upsetting diners at Thornbury Castle, ST6390 in August (AFJ); a juvenile male found floating in the River Avon at Keynsham, ST6569 on 10 August was caught, and released at the site on the 18th (AFJ). A male of Type I found exhausted at Westbury-on-Trym on 14 September was released to the wild. A male was collected from Portishead on 15 September after being driven around Bristol impaled on a taxi's radio aerial.

A male at Clevedon, ST4070 in February was cat-damaged, as was a male at High Littleton, ST6458 on 23 July. Other records, mainly of bats found injured (often by cats), from the following locations (all AFJ/DD): ST3663, 4466 (two), 4975, 5178, 5257, 5271, 5369, 5568, 5673, 5769, 5774, 5775, 5778, 5789, 5982, 6073, 6161, 6175, 6274, 6355, 6371, 6372, 6468, 6489, 6490, 6553, 6567, 6576, 6589, 6658, 7055, 7288, 7363, 7381, 7382.

LAGOMORPHA (rabbits and hares)

Brown hare *Lepus europaeus.* The National Brown Hare survey continued. R. Howard reported a hare in ST6465 in January - his first sighting for some time.

RODENTIA (rodents)

Common rat *Rattus norvegicus.* Mr R. H. Bevan (Pest Control Manager, Bristol

City Council) reported on the continuing decline in numbers of rat problems with 979 cases investigated (cf. 1,074 in 1991; 1,113 in 1990; and 1,348 in 1989).

House Mouse *Mus domesticus*. Mr Bevan reported a further decline in the numbers of house mouse complaints in Bristol, with 1,282 cases investigated (cf. 1,319 in 1991; 1,657 in 1990; but 1,289 in 1989).

Dormouse *Muscardinus avellanarius*. Dr Paul Bright's work on dormouse conservation continued. One of the "key sites" where populations are being closely monitored is in Somerset. David Clarke continues to monitor the success of the dormouse boxes in woodland near Cleeve.

Harvest Mouse *Micromys minutus*. R. Howard reported that his cat had "collected" a harvest mouse in ST6465 in August.

CARNIVORA (carnivores)

Fox *Vulpes vulpes*. Numerous records from throughout the county.

Mink *Mustela vison*. The Mink (Keeping) Order 1992, laid before Parliament on 25 November, came into force on 1 January 1993. It will be reviewed after 1998.

Badger *Meles meles*. Badgers continue to make the headlines. The Protection of Badgers Act 1992 came into force on 16 October; it consolidates the Badgers Act 1973, the Badgers Act 1991 and the Badgers (Further Protection) Act 1991.

Otter *Lutra lutra*. The Wessex Otter Conservation Project surveyed rivers in Avon over the past year and reports some positive records for otters along the central part of the River Avon. Details of the locations remain confidential.

ARTIODACTYLA (deer)

Muntjac *Muntiacus reevesi*. A survey of numbers and distribution is being undertaken by Prof. S. Harris and Norma Chapman.

Roe deer *Capreolus capreolus*. Reports from ST6465, ST7474 and ST7577.

Sika deer *Cervus nippon*. In March 1992 the sika deer was added to Schedule 9 of the Wildlife and Countryside Act 1981. It is now an offence to release, or allow to escape into the wild, any sika deer without a licence.

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BRISTOL BOTANY IN 1992

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In a year in which the temperature overall (10·1°C) was very close to normal, 1992 started with a fairly mild three months, averaging 0·4°C above the norm. In this period (January - March) there were only 23 ground frosts, compared with 48 in 1991. Vernal species were quite well advanced; snowdrops flowered in early February at Woollard and by the middle of the month at Uphill, Coley and Compton Martin Wood, with *Helleborus foetidus* in Goblin Combe and *H. viridis* at Nettlebridge flowering at the end of the month (RSC). April temperatures were close to average, but May was the warmest for a great many years (1·9°C above average) and promoted fairly early flowering which was largely maintained throughout the year, although October was very cold. Rainfall for the first six months was about 16% below normal but the extremely wet August (181·3 mm) and November (209·7 mm) made 1992 the wettest year since 1981. Total annual rainfall at Long Ashton Research Station, to which all meteorological records relate, was 1018·7 mm, about 116% of the long term average. Although garden trees and shrubs generally flowered and fruited well, *Sorbus* performed poorly in the wild for a second year, with only little flowering and fruiting (PJMN).

Recent investigations of the isoenzymes of taxa of *Sorbus* include specimens from the Avon Gorge and Mendip (M.C.F. Proctor and A.C. Groenhof, 1992, Peroxidase isoenzyme and morphological variation in *Sorbus* L. in South Wales and adjacent areas, with particular reference to *S. porrigentiformis* E.F. Warb., *Watsonia,* 19, 21-37). The findings prove consistent with the taxonomic views for the Bristol rarities *S. bristoliensis* and *S. wilmottiana.* Peroxidase evidence links the Avon Gorge and Mendip *S. eminens* and suggests affinity with *S. hibernica.* A uniform population of *S. porrigentiformis* in the Leigh Woods quarries is found to differ from plants elsewhere named this and needs further study. In the paper by P.D. Sell on the *Sorbus latifolia* aggregate in the British Isles (*Watsonia,* 1989, 17, 385-399), *Sorbus decipiens* is given (p.387) as planted and regenerated in the Avon Gorge, v.c. 6, but this species is known only on the Gloucestershire side (v.c. 34) of the Gorge (*Bristol Botany in 1989*, p.40). This error is also in Stace's *New Flora of the British Isles*, 1991, p.450.

Much interesting comment and many details are included in the article 'An introduction to street trees in Bristol' by A.C. Titchen and the late A.L. Grenfell in these *Proceedings* for 1991 (Vol. 51, pp. 41-61). Although three well-known street trees - London Plane, Common Lime and Norway Maple - make up some 80% of the total, the comprehensive list is a long one, and includes such rarities as the Dawn Redwood, Giant Redwood, Tulip Tree, Tree of Heaven and Indian Bean Tree.

Some floristic changes in Bourton Combe, S, have been established by PJMN. A detailed study of the Combe (including the approaching lane) was made in 1965-66 by the late Dr A. F. Devonshire in connection with the work of the Conservation Committee of the Bristol Naturalists' Society. He listed 173 species and noted that J.W. White's *Flora of Bristol* (1912) indicated the presence of five showy aliens:

Doronicum pardalianches, *Petasites fragrans*, *Aconitum napellus*, *Geranium versicolor* and *Heracleum giganteum* (*H. mantegazzianum*). Of these only *D. pardalianches* and *P. fragrans* remained when Dr Devonshire made his list, and both still persist (PJMN). *Impatiens parviflora*, known there since 1943, was given by Dr Devonshire as abundant in woodland; it remains well established in the northern part of the Combe (PJMN). Recorded in White's *Flora* but not seen by Dr Devonshire are *Cystopteris fragilis*, *Blechnum spicant*, *Symphoricarpos albus* and *Rubia peregrina*, all persisting although *R. peregrina* is rare (PJMN). Recent colonists may include *Rhamnus cathartica* (one very small plant) and *Saxifraga hirsuta*; a single large colony of *Galium odoratum* in the higher reach of the Combe has also not previously been reported (PJMN).

As often noted in previous years, several species not recorded for nearly a century or more have been found again in formerly known localities. Of particular note in 1992 are *Potamogeton lucens* in the River Frome, *Gagea lutea* at Great Elm and *Orchis morio* on Clifton Down, Bristol. Additional stations have been reported for many species, some of which are very rare in the Bristol area. The site for *Lepidium latifolium* near Wookey is the only one currently known for this species in v.c. 6. Other notable finds are of *Paris quadrifolia* in a part of v.c. 34 where not formerly reported, of *Ribes alpinum* near Wells, of a second current North Somerset locality for *Callitriche truncata*, of *Potamogeton trichoides* at Kingston Seymour and other parts of the Avon Levels and Moors and of the grass hybrid *Elytrordeum langei* at Highbridge and Aust. Additional localities for *Montia fontana* probably reflect the previous under-recording of this plant. Critical field work has yielded further records of *Hieracium* and of hybrids of *Rosa*.

Names of contributors associated with several records, or with the determination of specimens, are abbreviated thus:

JB	J. Bevan	MARK	M. A. R. Kitchen
SHB	S. H. Bishop	ACL	Dr A. C. Leslie
CJC	C. J. Cornell	EJM	Mrs E. J. McDonnell
RSC	R. S. Cropper	PJMN	P. J. M. Nethercott
GAC	Miss G.A. Crouch	EGMN	E.G.M. Niblett
IFG	Miss I.F. Gravestock	RDR	R.D. Randall
IPG	I.P. Green	TCGR	Dr T.C.G. Rich
PRG	P.R. Green	AGS	A.G. Smith
CK	Mrs C. Kitchen	DW	D. Warden

The area covered by this report is essentially that defined by J. W. White for his *Flora of Bristol* (1912). The eastern boundary is taken as the old boundary of Wiltshire where it meets the old boundaries of Gloucestershire and Somerset. The southern limit is taken as approximately the course of the River Brue along some of its length. The area comprises the northern part of the Watsonian vice-county of North Somerset (v.c. 6) and the southern part of West Gloucestershire (v.c. 34). In the following records these parts are designated S and G respectively.

Plant names are in accordance with C. Stace's *New Flora of the British Isles*, 1991.

Asplenium adiantum-nigrum L. One plant on disused railway bridge, Ham Green, MARK & CK.

A. obovatum Viv. ssp. *lanceolatum* (Fiori) Pinto da Silva A few plants, Frome

Valley, Bristol, G, MARK. This Spleenwort is exceedingly rare in the Bristol district.

A. marinum L. Still in fair quantity, Spring Cove, Weston-super-Mare, S, MARK & CK.

Ophioglossum vulgatum L. On steep bank and also nearby on small unimproved bank in improved grass ley, Bevington, G, MARK & Mrs B. A. Grindey.

Ranunculus parviflorus L. In 1990, fairly bare slope, Henham, Woolverton, S, IPG. The Small-flowered Buttercup has not been recorded in this part of Somerset since 1944.

Aquilegia vulgaris L. A single plant, Bourton Combe, S, PJMN, where probably native but not previously reported. Three plants in grassland, Callow Hill, near Axbridge, S, and in two places in grassland near Mogg's Wood, south of Clapton-in-Gordano, S, RSC.

Ceratophyllum demersum L. In 1990, Orchardleigh Lake, north of Frome, S, IPG. Still present and also *Potamogeton pectinatus* L., RSC.

Papaver argemone L. Sea bank, Brean, S, IPG.

Lepidium heterophyllum Benth. Locally abundant, Bury Hill Camp, G, MARK & CK.

L. latifolium L. Along stretch of bank of rhyne, Leaze Drove, Henton, Wookey, S, Miss A. P. Pockson. This is the only present-day locality for Dittander in v.c. 6.

Hornungia petraea (L.) Reichb. In quantity on roof of Gallery, St Vincent's Rocks, Bristol, G, RSC, where recently colonized.

Viola canina L. In small quantity, edge of Golf Course, Ashton Hill, Long Ashton, S, MARK & CK, conf. TCGR.

Hypericum maculatum Crantz ssp. *obtusiusculum* (Tourlet) Hayek Dulcote Hill, Dulcote, S, Miss V. Copp & CJC.

H. × *desetangsii* Lamotte (*H. maculatum* Crantz × *H. perforatum* L.) In rough field below Mascall's Wood, Cheddar, S, P. A. Harmes, conf. Dr N. K. B. Robson.

H. pulchrum L. In 1990, Kingcopse Wood, Norton St Philip, S, PRG & IPG. Plentiful in rough grassland, with *H. montanum* L. nearby, Callow Hill, Sidcot, S, RSC.

Cerastium semidecandrum L. Abundant on Carboniferous Limestone on old quarry floor and in nearby grassland, Wick Rocks, G, MARK & CK.

Stellaria pallida (Dumort.) Piré In small quantity in grassland, Brandon Hill, Bristol, G, MARK & CK.

Arenaria serpyllifolia L. ssp. *leptoclados* (Reichb.) Nyman Lane, Hallen, near Bristol, G, IFG; *Linaria repens* (L.) Miller is persistent here.

Spergularia rubra (L.) J. S. & C. Presl Still at Rodway Hill, near Mangotsfield, G, MARK & CK, where stated by J.W. White, *Flora of Bristol*, 1912, p. 197, to be formerly abundant but 'now beset by golfers'. Persistent in tiny quantity, Humpty Tumps, Keynsham, S, MARK & CK.

Montia fontana L. ssp. *minor* Hayw. Small areas of acid grassland above River Frome valley, Oldbury Court Estate, Bristol, G; abundant in short turf in several areas on Millstone Grit, Tyndall's Park, Bristol, G; and locally abundant on shallow soil on Millstone Grit, Brandon Hill, Bristol, G; all records MARK & CK. Rocky outcrops, Ashton Court Park, Bristol, S, MARK, CK, RDR, AGS, N. J. Ray *et al.* Small patch in short turf on Millstone Grit, edge of Golf Course, Ashton Hill, Long Ashton, S, MARK & CK.

Chenopodium ficifolium Smith On disturbed ground, Southmead, Bristol, G, MARK. Arable weed, Hinton Charterhouse, S, RSC; peat cutting, Walton Heath, S, RSC; and, with *C. polyspermum* L., field, Churchill, S, RSC.

C. murale L. In 1991, Dairy House Farm, Beckington, S, IPG. Also garden weed, Berrow, S, PRG.

Salicornia dolichostachya Moss Plentiful, with *S. ramosissima* J. Woods, along shore and on sea-wall, Kingston Seymour, S, RSC.

Tilia platyphyllos Scop. One tree by disused railway line, Warmley, G, MARK, CK & SHB.

Erodium maritimum (L.) L'Hér. Single rosette in path, Anchor Head, Weston-super-Mare, S, MARK & CK.

Trifolium striatum L. In two sites in good quantity, Ashton Court Park, Bristol, S, MARK, CK & T. N. Twiggs.

T. scabrum L. Still on the earthworks where locally abundant in a small area, Observatory Hill, Clifton, Bristol, G, MARK & CK.

T. micranthum Viv. Several plants in lawn, Weston-super-Mare, S, RSC.

Anthyllis vulneraria L. Hawkesbury Upton, G, RSC, where also *Hippocrepis comosa* L., *Blackstonia perfoliata* (L.) Hudson, *Carex viridula* Michaux ssp. *oedocarpa* (Andersson) B. Schmid (*C. demissa* Hornem.), *C. panicea* L. and *Koeleria macrantha* (Ledeb.) Schultes.

Vicia bithynica (L.) L. In 1990, persistent on bank of disused railway, Kilmersdon, S, PRG & IPG, where reported as plentiful in 1980 by D. E. Green (*Bristol Botany in 1980*, p. 101).

Agrimonia procera Wallr. Flowering well on grassy roadside, Chantry, S, and persistent in Asham Wood, S, RSC.

Aphanes inexspectata Lippert Abundant on the ramparts, Bury Hill Camp, G; small areas of acid grassland, Oldbury Court Estate, Bristol, G; abundant on shallow soil, Brandon Hill, Bristol, G; all MARK & CK.

Rosa × *verticillacantha* Mérat (*R. arvensis* Hudson x *R. canina* L.) A fine bush, with both parents nearby, Inglestone Common, G, RSC.

R. stylosa Desv. Single bushes on ditch banks in three sites, Kingston Seymour, S, PJMN. Formerly very abundant in these lowland areas (J.W. White, *Flora of Bristol,* 1912, p. 298).

R. × *dumalis* Bechst. (*R. caesia* Smith ssp. *glauca* (Nyman) G. G. Graham & Primavesi × *R. canina* L.) Lodge Hill, Westbury-sub-Mendip, S, PRG, det. Rev. A. L. Primavesi.

R. tomentosa Smith One bush in scrubby limestone grassland, Cleaves Wood, near Hinton Charterhouse, S, RSC.

R. sherardii Davies Several bushes in rocky combe, Charterhouse, S, IPG, PRG & GAC, det. Rev. A. L. Primavesi.

R. rubiginosa L. About ten bushes in limestone grassland, Binegar, S, RSC.

R. micrantha Borrer ex Smith Still survives, but in very small quantity, Clifton and Durdham Downs, Bristol, G, PJMN. A few bushes in scrub, Loxton Hill, S, RSC.

Crataegus × *macrocarpa* Hegetschw. (*C. monogyna* Jacq. × *C. laevigata* (Poiret) DC.) A single specimen by track in wood, Catgrove, near Lower Stone, G, MARK, CK, TCGR & Miss E. M. Nic Lughadha.

Sorbus torminalis (L.) Crantz One large old tree, grown from a pollard, at edge of wood, Priest Wood, near Cromhall, G, MARK. Also a single spindly standard on southern rim of River Frome valley, Glen Frome, Bristol, G, MARK & CK. A single tree was reported from Oldbury Court Wood last century (J. W. White, *Flora of Bristol,* 1912, p. 309). Compton Wood, Compton Martin, S, PJMN.

Saxifraga hirsuta L. Well established in a small disused and unfrequented old quarry, Bourton Combe, S, PJMN. This probably started as a small garden throw-out but is likely to become a permanent member of the Combe flora.

Myriophyllum spicatum L. Good quantity in rhyne near Crook's Marsh, G, MARK.

Callitriche truncata Guss. In small quantity, River Banwell, near East Rolstone, S, R. Higgins and, later, MARK & CK. This is a second present-day locality for the Bristol district. Persistent in small quantity in rhyne, Kingston Seymour, S, MARK & CK, conf. C. D. Preston, where formerly recorded by Dr R. M. Harley (*Bristol Botany in 1967*, p. 351).

Torilis nodosa (L.) Gaertner Good patch on dry bank by the River Severn, Cowhill Warth, near Oldbury-on-Severn, G; still quite plentiful at Brandon Hill, Bristol, G, MARK & CK. In quantity on steep bank, Ashton Court Park, Bristol, S, MARK, CK & T. N. Twiggs; plentiful on bank by salt marsh, south of Gullhouse Point, Clevedon, S, MARK & CK. A few plants on rocky bank, Nyland Hill, S, RSC.

Petroselinum segetum (L.) Koch Abundant in several places, west-facing dry bank by the Severn, Cowhill Warth, near Oldbury-on-Severn, G, MARK & CK. A good patch, hedgebank, rear of salt marsh, south of Gullhouse Point, Clevedon, S, MARK & CK; also on north bank of the River Axe, Webbington, S, MARK.

Berula erecta (Hudson) Cov. In rhyne, near Crook's Warth, G, MARK.

Euphorbia platyphyllos L. Appeared annually for some years in the grounds of Southmead Hospital, Bristol, G, MARK, but only one plant seen in 1992 (did not fruit) and likely to disappear with building developments.

Rumex × *sagorskii* Hausskn. (*R. crispus* L. × *R. sanguineus* L.) Several plants in field above Mascall's Wood, Cheddar, S, ACL.

R. pulcher L. One plant in sandy turf, Ellenborough Park, Weston-super-Mare, S, RSC. Also *Lavatera arborea* L. on roadside.

R. × *abortivus* Ruhmer (*R. conglomeratus* Murray × *R. obtusifolius* L.) Chilton Moor, Burtle, S, EJM & J. Clarke, det. Dr J. R. Akeroyd.

Populus nigra L. ssp. *betulifolia* (Pursh) W. Wettst. Single standard in hedge, Old Sodbury, G, MARK.

Salix purpurea L. Single tree in small carr, St Anne's Well, Webb's Heath, near Warmley, G, MARK & CK. The Purple Willow is now very rare in west Gloucestershire. By ponds in quarries, Emborough, S, and plentiful around upper reservoir, Litton, S, PRG. One bush in pond by railway, Lympsham, S, IPG.

S. × *multinervis* Doell (*S. cinerea* L. × *S. aurita* L.) Chickwell, Hemington, S, PRG.

Calluna vulgaris (L.) Hull A few young plants, Bury Hill Camp, G, MARK & CK.

Anagallis tenella (L.) L. Small patch, wet ditch in fen meadow, Churchill, S, RSC.

Centaurium pulchellum (Sw.) Druce In thin turf at edge of old quarry, Cross, S, RSC.

Symphytum tuberosum L. King's Wood, Cross, S, H. Squires.

Chaenorhinum minus (L.) Lange An occasional survival in Abbots Leigh parish, S, on abandoned railway track to Portishead opposite to Sea Mills, G, across the River Avon, PJMN. Edge of track, Churchill, S, and in old quarry, Cloford, S, RSC.

Kickxia elatine (L.) Dumort. Old quarry floor, Tytherington, G, MARK.

Veronica catenata Pennell Inglestone Common, G, RSC, where also two small flowering plants of *Ranunculus ophioglossifolius* Villars.

V. spicata L. ssp. *hybrida* (L.) Gaudin A few spikes with white flowers, with plenty of blue, St Vincent's Rocks, Avon Gorge, Bristol, G, AGS & Ms L. Houston.

Pedicularis palustris L. One plant, damp meadow, Nettlebridge, S, J. Poingdestre.

Orobanche rapum-genistae Thuill. On bank under Broom and Gorse, Chilwood, S, MARK & CK.

O. hederae Duby Abundant in lane where not seen before despite visits over many years, Stoke Bishop, Bristol, G, IFG. Also on waste ground here *Chenopodium polyspermum* L., *Epilobium lanceolatum* Sebast. & Mauri, *Odontites vernus* (Bellardi) Dumort., *Carduus nutans* L., *Senecio cineraria* DC. and *Triticum aestivum* L., IFG.

Thymus pulegioides L. Several patches in limestone grassland, Knowle Hill, West Compton, S, RSC. Also *Campanula rotundifolia* L.

Clinopodium acinos (L.) Kuntze Several in old quarry, Cloford, S, RSC. Also *Oenothera cambrica* Rostanski and nearby *Cirsium eriophorum* (L.) Scop., RSC.

Stachys arvensis (L.) L. A plant in flower bed, Warmley, G, MARK, CK & SHB.

S. × *ambigua* Smith Two good patches, Old Lox Yeo, Webbington, S, MARK. Road bank, Midsomer Norton, S, IPG.

Lamium hybridum Villars In 1990, Buckland Dinham, S, PRG & IPG.

Galeopsis tetrahit L. With white flowers, Charterhouse, S, RSC.

G. bifida Boenn. Scrubby open woodland, Chelwood, S, MARK & CK.

Scutellaria minor Hudson A single non-flowering plant from which overshading Bracken and Bramble were cleared, Rodway Hill, near Mangotsfield, G, MARK &

CK. Despite searching, not seen in the previous two years.

Dipsacus pilosus L. One plant on north bank of the Little Avon River, Damery Bridge, G, MARK & CK. On bank of the River Chew, Compton Dando, S, RSC.

Senecio sylvaticus L. Persists in good quantity, Bury Hill Camp, G, MARK & CK.

Filago minima (Sm.) Pers. Very plentiful, edge of Moons Hill Quarry, Stoke St Michael (Stoke Lane), S, IPG.

Anthemis arvensis L. Sides of new road, where probably sown, Hutton Moor, Weston-super-Mare, S, MARK & CK. Also *Calendula arvensis* L. and *Centaurea cyanus* L.

Carduus tenuiflorus Curtis Persistent by old quarry, Cross, S, RSC.

Serratula tinctoria L. One plant on unimproved neutral pasture by the Severn, Cowhill Warth, G, MARK & CK.

Hieracium diaphanum Fries In substantial quantity, Troopers Hill, Conham, G, and also Rodway Hill, G, MARK, CK, RDR & JB, det. JB.

H. sabaudum L. In old railway cutting, Siston Common, G; plentiful on west-facing slopes, Rodway Hill, G; waste ground, Warmley Station, G; all MARK, CK, RDR & JB, det. JB.

H. salticola (Sudre) Sell & C. West Abundant on waste ground, and a few on disused railway line, Warmley Station, G, MARK, CK, RDR & JB, det. JB. This is a second locality for south-west Gloucestershire.

Baldellia ranunculoides (L.) Parl. In mown field, where arable crops formerly grown, Catcott, S, AGS, and also *Veronica catenata* Pennell and *Glyceria* × *pedicellata* F. Towns.

Butomus umbellatus L. A large clump on bank of the River Avon between Saltford and Bath, S; also persistent in Ham Green Lake, S, EGMN.

Potamogeton lucens L. In River Frome, Farleigh Hungerford, S, IPG. The Shining Pondweed has not been recorded in the River Frome since 1873.

P. berchtoldii Fieber In 1990, margin of Orchardleigh Lake, north of Frome, S, IPG; still present in 1992, RSC. Rhyne, Kingston Seymour, S, PJMN.

P. trichoides Cham. & Schldl. Locally abundant in rhyne, Kingston Seymour, S, MARK & CK, det. C. D. Preston. In rhynes, Tickenham Moor, Nailsea Moor, Clevedon Moor, Kenn Moor, Kingston Seymour, near Wick St Lawrence, East Rolstone and near Locking, S, Ms K. Pollock, English Nature Avon Levels and Moors Survey, 1991-92. This Pondweed, which appears to be distributed quite widely in the Avon Levels, has previously been reported in North Somerset only from Blagdon Lake in 1934 (see *Bristol Botany in 1954*, pp. 21-22).

Groenlandia densa (L.) Fourr. R Banwell, near East Rolstone, S, MARK & CK.

Gagea lutea (L.) Ker Gawler In 1988 in steep grassy field, Stoke St Michael (Stoke Lane), S, Mr & Mrs T. Andrews. A few plants in wooded valley, Murdercombe, Great Elm, S, IPG & GAC, the first confirmed sighting here since 1900.

Paris quadrifolia L. In good quantity, Catgrove Wood, near Hill, G, MARK & Mrs B. A. Grindey; also a large colony in nearby Roundhouse Wood, G, MARK, CK,

TCGR & Miss E. M. Nic Lughadha. These records of Herb Paris on the Hill plateau are the first for this part of v.c. 34. Still in Priors Wood, Portbury, S, EGMN, where known in 1976 and 1977, but not in the intervening years.

Luzula multiflora (Ehrh.) Lej. Well scattered, Weston Moor, Gordano Valley, S, and also Westhay Heath in the Levels, S, RSC.

Spiranthes spiralis (L.) Chevall. A single spike in grassland, Stroud Common, Alveston, G, MARK & CK. In good quantity in Carboniferous Limestone grassland, Tytherington Camp, G, MARK & CK. Persistent in oolitic grassland, Nibley Knoll, North Nibley, G, MARK. One plant, Golf Course, Clevedon, S, EGMN.

Neottia nidus-avis (L.) Rich. In shade of beech, Mogg's Wood, south of Clapton-in-Gordano, S, RSC. Also *Veronica montana* L.

Ophrys apifera Hudson Well-grown plants, Cribbs Causeway, near Patchway, G, P. J. Chadwick. One plant, Hawkesbury Upton, G, RSC. Gordano By-Pass, S, EGMN. A single plant, old road, Chew Valley Lake, S, DW. Hillside, South Stoke, S, and Cleaves Wood, near Wellow, S, RSC.

Orchis morio L. One plant in unmown rough grass, Clifton Down, Bristol, G, K. B. Taylor, conf. Dr M. H. Martin. Two plants were noted in this vicinity, as 'an interesting survival' in 1925 (*Bristol Botany in 1925*, p. 236). Plentiful in mowing grass, Chew Valley Lake, S, DW. Abundant in several places, Uphill, S, RSC, where several pink-flowered plants and also purple and white.

Anacamptis pyramidalis (L.) Rich. In limestone valley, Hawkesbury Upton, G, RSC. Lane, Wraxall, S, P. J. Chadwick. Plentiful on road verge, Hursley Hill, Whitchurch, S, DW. Gordano By-Pass, S, EGMN. Hillside, South Stoke, S, Callow Hill, S, and one plant on west slope, Cross Plain, S, RSC.

Arum italicum Miller ssp. *neglectum* (F. Towns.) Prime In lane approaching Bourton Combe, S, PJMN. Eaker Hill, Chewton Mendip, S, PRG.

Schoenoplectus lacustris (L.) Palla Two good clumps in recently dug cutting, Shapwick Heath, S, RSC.

Cyperus longus L. One clump in farm pond, Webb's Heath, near Warmley, G, and abundant in fairly recently constructed pond, where probably planted, Nibley Green, North Nibley, G, MARK & CK. Stream bank, Chilcompton, S, IPG. Three large flowering clumps bordering Blake's Pools behind sea-wall at mouth of the Yeo, Kingston Seymour, S, RSC.

Carex pilulifera L. Retains a tenuous foothold, Rodway Hill, G, MARK & CK. Fruiting in grassland, Priddy, S, and in rough grassland, Wavering Down, S, RSC.

C. montana L. Persistent in old mining ground, but much reduced, Fernhill Farm, east of Charterhouse, S, RSC. Also *Lathyrus linifolius* (Reichard) Baessler (*L. montanus* Bernh.), RSC.

C. × *pseudaxillaris* K. Richter A good clump with the parents *C. otrubae* Podp. and *C. remota* L. at edge of rhyne, near Crook's Marsh, Avonmouth, G, MARK. Single clump by roadside, Kingston Seymour, S, MARK & CK.

C. muricata L. ssp. *lamprocarpa* Čelak. Bury Hill Camp, G, MARK & CK.

Poa nemoralis L. Whiteway, Dursley, G, RSC.

Catabrosa aquatica (L.) P. Beauv. Roadside ditch between Panborough and Mudgley, near Wedmore, S, J. O. Mountford, per EJM.

Bromus commutatus Schrader Inglestone Common, G. Tealham Moor, S, Catcott Burtle, S, and West Huntspill, S. All records RSC.

× *Elytrordeum langei* (K. Richter) N. Hylander (*Elytrigia repens* (L.) Desv. ex Nevski × *Hordeum secalinum* Schreber) With both parents, abundant in several places on salt marsh, Old Passage, Aust, G, MARK & CK. The hybrid was first found in this locality by Dr S. O'Donnell in 1991, det. Dr T. A. Cope. Scattered in field, landward of sea-bank, Highbridge, S, IPG, det. Dr T. A. Cope. This intergeneric hybrid was first discovered in the British Isles in August 1945 by Mrs C. I. Sandwith in brackish pasture by the Avon at Shirehampton, G, and was refound there in 1954, with both parents, by Mrs C. I. and N. Y. Sandwith (*Bristol Botany in 1954,* pp. 22-23; *Proceedings of the Botanical Society of the British Isles*, Vol. 1, 1955, p. 323 and p. 387).

Calamagrostis epigejos (L.) Roth Waste ground, Warmley, G, MARK, CK & SHB. Fairly large patch, Blackdown, Mendip, S, MARK & CK. Small patch in developing scrub, Walton Heath, near Ashcott, S, RSC.

ALIENS

Azolla filiculoides Lam. Pond in disused quarry by old railway line, Warmley, G, MARK, CK & SHB. In 1991, in River Frome, Selwood, S, PRG & IPG. West Huntspill, S, RSC.

Rapistrum rugosum (L.) Bergeret ssp. *linneanum* (Cosson) Rouy & Fouc. Several small patches, upper salt-marsh, Chittening Warth, G, and one plant at edge of cereal field, Hawkesbury Upton, G, MARK & CK. Waste ground, Glastonbury, S, PRG.

Isatis tinctoria L. Allotments, Ashley Vale, Bristol, G, Mrs A.J. Coates, det. AGS. Also double form of *Saponaria officinalis* L.

Descurainia sophia (L.) Webb ex Prantl A few plants, disturbed road bank, Eastertown, S, PRG.

Agrostemma githago L. Faulkland, Hemington, S, IPG. Road bank, probably garden escape, Brean, S, IPG.

Securigera varia (L.) Lassen (*Coronilla varia* L.) Persistent (see *Bristol Botany in 1983,* p.70) as large patch in grass, Shipham, S, D. Maxwell.

Duchesnea indica (Andrews) Focke Well established patch, Brandon Hill, Bristol, G, and good sized patch on northern rim of River Frome Valley, Broomhill, Bristol, G, MARK & CK. Large patch, road verge, Glastonbury, S, PRG.

Cotoneaster × *suecicus* Klotz (*C. dammeri* C. Schneider × *C. conspicuus* Marquand) In 1990, Lullington, S, IPG, det. J. Palmer.

Sedum dasyphyllum L. In 1990, Faulkland, Hemington, S, IPG.

Ribes alpinum L. Large stand in damp wood, Welsh's Green, Wells, S, CJC. This is the first record for Somerset since 1891.

Oenothera biennis L. One plant on beach, Sand Bay, S, RSC, with *O. cambrica*

Rostanski and *O. glazioviana* Micheli ex C. Martius. Also one plant by pavement, Burnham, S, RSC.

Torilis arvensis (Hudson) Link Seeding in cut cereal field, west of Ashton Hill near Keynsham, S, RDR and, later, MARK & CK. This is the only known present-day locality for this Umbellifer in the Bristol district.

Soleirolia soleirolii (Req.) Dandy Along road, outside garden, Stoke Bishop, Bristol, G, IFG. Also nearby *Agrostis gigantea* Roth.

Cyclamen hederifolium Aiton Two small clumps under hedge on road verge, a little distance from buildings, Ellick, near Blagdon, S, MARK.

Symphytum asperum Lepechin Along track, Theale, S, PRG, det. ACL.

S.× uplandicum Nyman Plentiful near lane, Cleeve, S, RSC.

S. grandiflorum DC. Edge of stream, Hale Coombe, Winscombe, S, EJM.

Calystegia pulchra Brummitt & Heyw. On roadside, Vole, near Mark, S, and a patch in roadside hedge, Burnham-on-Sea, S, RSC.

Nicandra physalodes (L.) Gaertner One plant, waste ground, Berrow, S, GAC.

Campanula rapunculoides L. Large patch, Torehole Bottom, Chewton Mendip, S, IPG.

Lagarosiphon major (Ridley) Moss Abundant in brackish Blake's Pools at mouth of the Yeo, Kingston Seymour, S, RSC.

Aponogeton distachyos L. f. Deep pond, Rickford Mill, near Burrington, S, EJM.

Lilium martagon L. Two well-established clumps, Leigh Woods, Bristol, S, Dr C. M. Lovatt.

Galanthus nivalis L. × *G. plicatus* M. Bieb. With both parents, Farleigh Hungerford, S, GAC & IPG. Also side of track, Rode, S, PRG.

Iris versicolor L. Large stand, edge of Emborough Pool, Emborough, S, PRG.

Lemna minuta Kunth Abundant in one part of rhyne, Kingston Seymour, S, MARK & CK. In 1991 abundant and colonizing open water, Westhay Heath, S, IPG. This Duckweed is very common in the Somerset Levels.

Bromopsis inermis (Leysser) Holub Roadside, Nettlebridge, S, PRG. On soil heap, Highbridge, S, IPG.

Ceratochloa carinata (Hook. & Arn.) Tutin (*Bromus carinatus* Hook. & Arn.) Bank of Blagdon Lake, Blagdon, S, PRG, conf. Capt. R. G. B. Roe.

Gaudinia fragilis (L.) P. Beauv. Barrow Hill, Panborough, S, PRG.

Digitaria sanguinalis (L.) Scop. About a dozen plants in 1991 and slightly fewer in 1992, in cracks along walls and pavement, Clifton, Bristol, G, C. Parker. Plentiful around building, Berrow, S, IPG.

BRYOPHYTE

Nowellia curvifolia (Dicks.) Mitt. In small quantity on decaying wood, Compton Wood, Compton Martin, S, PJMN.

CHAROPHYTES

Chara vulgaris L. var. *vulgaris* Pool west of church, Berrow, S, RSC.

C. globularis Thuill. var. *globularis* In deep water of excavated scrape, Tealham Moor, S, RSC.

ACKNOWLEDGEMENTS

I thank everyone who has supplied records and helped with these, especially Mr I. P. Green, Mr M. A. R. Kitchen, Mr P. J. M. Nethercott and Captain R. G. B. Roe. I am indebted to Long Ashton Research Station for meteorological records.

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1) The editor welcomes original papers on the natural history of Avon and surrounding areas for consideration for publication in the *Proceedings*. Inexperienced authors may obtain advice from members of the Publications Committee. Authors should bear in mind that their readers will not usually be specialists in the particular subject, and that unnecessarily technical language can be a barrier to understanding.

2) All items for consideration should reach the editor by the end of February in each year. If there is likely to be a problem with this target date, please contact the editor in advance.

3) Manuscripts should be double-spaced, with wide margins, and on one side of the paper only. The author should retain a copy.

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5) Originals, not copies, of photographs, slides, line drawings, diagrams and maps should be submitted - they will be returned on request. Drawings and other diagrams should be not more than twice final size, and made in black medium. Photographs and slides may be submitted as prints, positives or negatives, preferably in monochrome. Graphs, charts and simple diagrams may most readily be produced by computer graphics; advice and help with this are available.

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   e.g. RACKHAM, O. (1986). *The history of the countryside*. London, J. M. Dent.

   Paper AUTHOR (DATE). Title. *Journal name*, volume, part, page numbers.

   e.g. ROSS, S. M. & HEATHWAITE, A. L. (1986). West Sedgemoor: its peat stratigraphy and peat chemistry. *Proceedings of the Bristol Naturalists' Society*, **44**, 19-25.

7) It is very helpful if the text can also be submitted on a magnetic disk readable under MS-DOS (any version), either as an ASCII ("text" or "print" file) or as a file produced by *Ability Plus*, *Galaxy*, *Word*, *Word Perfect* or *Wordstar* software. For other formats, please enquire. A disk version is especially valuable when many scientific names or specialised terms are involved.

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AVON WILDLIFE TRUST AND ITS NATURE RESERVES

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ABSTRACT

This paper briefly summarises the nature reserves under the Trust's management and discusses how they fit into the Trust's work as a whole. The benefits of managing land as nature reserves are discussed. Seven reserves (Dolebury Warren, Brown's Folly, Stockwood Open Space, Clevedon Court Woods, Weston Moor, Chew Valley Lake and Brandon Hill, Bristol) have been used to illustrate the range of problems encountered in managing reserves and the variety of strategies that have been adopted to make the most of these sites. The future role of the Trust in relation to reserves is briefly discussed.

INTRODUCTION

The Avon Wildlife Trust (AWT), as with similar organisations elsewhere, spends much of its time trying to safeguard the wildlife resources of the county. This means working on many fronts: influencing national land-use policies and the planning system, advising landowners and managers, supporting the Farming and Wildlife Advisory Group, working with local authorities to produce conservation strategies and acquiring and managing nature reserves. Here we concentrate on the most public and most time-consuming of these tasks - the acquisition and management of nature reserves.

At its launch in May 1980 the AWT owned four reserves, inherited from the Somerset Trust for Nature Conservation. By the end of 1982 this number had increased to sixteen. Backed by a large labour force employed through schemes such as the Community Programme funded by the Government's Manpower Services Commission, the Trust continued to acquire reserves through most of the 1980s. In 1988 the Community Programme ended and the Trust no longer had the resources to establish new reserves. Since Folly Farm was acquired in 1987 only one new reserve - Netcott's Meadow in Nailsea - has been taken on.

In the early years the acquisition of reserves largely reflected the opportunities that arose. In 1988, recognising the changing circumstances, the Trust drew up a comprehensive acquisition policy to guide the consideration of potential reserves and to allow the re-evaluation of those already existing. The over-riding factor when considering would-be reserves is whether the Trust has the resources to manage them. The long-term aims are to safeguard a representative cross-section of the county's wildlife habitats and to gain a good geographical spread in order to offer access to as wide an audience as possible. If there is to be any bias in the types of site acquired it will be towards rarer habitats such as some wetlands which are threatened or which need specialist management to retain their wildlife interest.

Today the AWT manages 28 nature reserves covering about 540 hectares (1,350 acres). They range in size from the 99 hectare Folly Farm to ten sites each of less than 5 hectares - small corners of land that were threatened by neglect. Almost half the area managed by the Trust is under broad-leaved or mixed woodland (257 ha), while limestone grasslands make up a further 98 hectares. The third largest habitat type is flower-rich neutral grassland; some 47 hectares of this rapidly vanishing habitat are safeguarded on the Trust's reserves. Most of the county's surviving heathland is found in small remnants at Dolebury Warren and Goblin Combe, while other interesting habitats include saltmarsh, lakes, fens and old quarries. Perhaps surprisingly, the Trust owns only five of these reserves, so the future of the rest depends to a large extent on the continuing goodwill of various landowners. However, at least parts of ten of the reserves have been designated Sites of Special Scientific Interest (SSSI) by English Nature. Information for people wishing to visit the reserves is available in a reserve guide issued free to Trust members.

BENEFITS OF MANAGING NATURE RESERVES

Probably the most widespread benefit offered by nature reserves is that they can be managed specifically to encourage wildlife. Many of AWT's reserves have been enhanced for wildlife over the years through implementation of better management or by the creation of new habitats. For instance, the Trust has managed to re-introduce grazing on five reserves which were becoming covered with scrub through neglect. The new regime of seasonal grazing should help to encourage the flora associated with the old grasslands on Middle Hope and elsewhere. A programme of coppicing and replanting has been carried out in plantations at Clevedon Court, Brown's Folly and Folly Farm to encourage their development into something more akin to our ancient broad-leaved woodlands. The ten ponds that have been created on various reserves are already a great attraction to amphibia and other aquatic life, while the ride that was created in Weston Big Wood soon developed into one of the best places in Avon to watch Silver-washed Fritillaries.

Another important role that a nature reserve can play is as a place where people can enjoy and learn about wildlife. Willsbridge Mill, with its superb exhibition and educational facilities, is the Trust's flagship in this respect but many other reserves have much to offer. There are additional permanent exhibitions put up by the Trust at Brandon Hill, Bristol and at Chew Valley Lake, while interpretative booklets are available for seven of the reserves. The Trust has often improved footpaths, and even created new ones, carefully trying to steer visitors away from more sensitive sites.

As well as providing the public with pleasant places to visit, the reserves have occasionally been used by the Trust to demonstrate forms of management to other land managers. Woodland managers have been shown the Trust's approach to storm damage at Clevedon Court Woods, while Brandon Hill Nature Park has given parks staff (as well as the general public) ideas to take away and try elsewhere.

RESERVES AND THEIR MANAGEMENT

AWT has learned a great deal through acquiring and managing nature reserves. The sections that follow look at a selection of the reserves, to show the breadth of work that has been carried out together with examples of the problems that have been encountered and solutions that have been found.

DOLEBURY WARREN

This classic example of Mendip's limestone grassland is undoubtedly one of the most important sites managed by the Trust. Here the general naturalist can admire the flower-rich downland turf, the keen botanist can search for Somerset Hairgrass and Slender Bedstraw, the lepidopterist can hunt for over thirty species of butterfly and the ornithologist can compare the songs of the many scrub warblers. Despite its inclusion in the Nature Conservation Review (Ratcliffe 1977) the only management the site had received this century, prior to the Trust's involvement, was the ploughing of some of the downland to create some grazing paddocks. Like many abandoned areas Dolebury changed drastically following the outbreak of myxomatosis which almost eradicated the rabbits, allowing coarse grasses and then shrubs to establish themselves across the hillside. Until the mid-1950s rabbits alone grazed the hill, retaining a classic short-cropped downland sward. After a further thirty years without interference drastic measures were required to recover the situation. Had its adoption as a reserve not coincided with the deployment of a huge new labour force by the Trust through the Government's Community Programme, Dolebury would probably still be succumbing to an advancing tide of scrub. The Trust's solution was to erect six miles of fencing and install a water supply so that the hill could be grazed by livestock. With the hard Carboniferous limestone virtually uncovered by soil this proved a monumental task. Work continued almost without a break for over a year and in the summer of 1985 sheep and cattle roamed the hill probably for the first time this century.

While the livestock were checking scrub encroachment, the Small Blue butterfly, one of the site's specialities, did not respond positively to their presence. Observers reported a serious decline in numbers in 1986 and some timely research suggested that the newly-arrived sheep might be the cause. The extinction of the Large Blue in Britain had stimulated considerable interest in the ecology of British butterflies and one species which had received attention was the Small Blue. Researchers had found that this butterfly lays its eggs in the flower heads of Kidney Vetch, and also that sheep are very partial to these same flowers. Since these findings the Trust has been careful to ensure that some areas of Kidney Vetch remain out of the reach of sheep each summer. Five years on, the sward has responded well enough to allow most of the downland to be left ungrazed between mid-May and late July.

A further opportunity arose to improve the management of Dolebury when in 1989 the Trust was forced to change its grazier. The new grazier keeps a larger flock of a harder breed of sheep (Shetlands) which have proved more effective in controlling the scrub - so much so that in 1991 the Trust undertook the enclosure of an area of heathland on the northern slopes that had previously been abandoned to the scrub and bracken. If this project proves successful the area of heathland in Avon could be doubled and so increase the populations of scarce species such as the Small Pearl-bordered Fritillary and Adder.

Dolebury was neglected for so long that there is a huge backlog of work still to be done. In an organisation with limited reources this presents the continual dilemma of deciding what work is most important. Since Dolebury includes a Scheduled Ancient Monument (designated because of its hill fort and other archaeological features) as well as a SSSI, it is therefore often a question of choosing between clearing scrub from the archaeological features or from the most floristically rich grasslands, which unfortunately do not overlap.

BROWN'S FOLLY

Brown's Folly Nature Reserve, like Dolebury Warren, benefits from calcareous soils but in this case derived from the softer Jurassic limestone of the Cotswold Hills. The huge reduction of the rabbit population since the 1950s has had an even more devastating effect on this reserve, so that today there are only remnants of the downland that used to run the length of Bathford Hill. The Trust deliberated long and hard as to whether the site could or should be grazed by livestock. The patchiness of the grassland, the steepness of the slopes, and the popularity of the site with dog walkers led us to decide against a Dolebury approach. Instead the Pyramidal Orchids and Dark Green Fritillaries are dependent on manual labour to keep open the grassland areas.

This is a classic example of a site where wildlife has benefited from the land's unsuitability for agriculture or other commercial uses. Ironically the steep slopes and poor access which have deterred farmers and developers also hinder the effective management of the habitats for wildlife. Aware that the Duke of Burgundy Fritillary and Musk Orchid had already become extinct on the site, the Trust decided to implement a somewhat controversial scheme rather than allow more areas to be neglected. The solution was to build an access track running for over a kilometre through the reserve. This rather drastic measure provides two major benefits. First, it allows volunteers and tools to be driven closer to where most of the work is, and secondly the track allows the Trust to remove timber from the extensive (and increasing) woodland, thus providing a valuable income to contribute towards the cost of the reserve's management. Large blocks of Corsican Pines, which are of limited wildlife value, have been removed and the cleared areas replanted with native broadleaved trees such as Oak and Wild Cherry. The aim of management is to create a structure and composition typical of ancient Cotswold woodlands, and a new home for some of the reserve's more unusual woodland plants like the White Helleborine and Stinking Hellebore.

While much of the woodland management is carried out by specialist contractors, the grassland areas are largely dependent upon volunteer labour. Each year many hours are spent cutting the vegetation with strimmers and grass-hooks and then meticulously raking off the cuttings to prevent a build-up of leaf litter. The Pyramidal Orchids, Dark Green Fritillaries and other grassland specialities are dependent on volunteers continuing to offer their services.

STOCKWOOD OPEN SPACE

Situated within the Bristol City boundary, the Stockwood reserve (Plate 1) offers the people of south-east Bristol an excellent opportunity to get to know some of the wildlife delights of our grasslands. This wedge of farmland missed the agricultural intensification seen elsewhere by a quirk of fate. Having bought the land for development the City Council then discovered that much of it was too unstable geologically to be built on. Rather than sell on the land the Council turned it into a public open space full of wildflowers. In summer parts of the reserve are ablaze with Cowslips, Dyer's Greenweed and Field Scabious, while a marshy corner still supports a healthy population of the ever dwindling Glow Worm.

How is a piece of urbanised farmland looked after? Without management the long established grassland communities would as ever succeed to scrub and then

Avon Wildlife Trust
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PLATE 1. Part of Stockwood Open Space, Bristol.

woodland, but a return to the traditional grazing regime is impracticable where there are so many dogs and people. The chosen approach has been to treat much of the land like an old hay meadow, taking a crop each July. As the land had been so long neglected the Trust had to give the grass away in order to attract a farmer to do the work. Unfortunately the local schoolboys have proved to be an influential factor in determining the cutting regime. After the Trust expanded the area to be cut for hay these boys turned pyromaniacs, setting fire to the drying hay. The Trust brought forward the cutting date to avoid the idle hours of school holidays but to no avail. The latest approach is to persuade a farmer to bag up the grass for silage, so avoiding the need to leave it lying around. This is a poor compromise in conservation terms, as much seed returns to the ground only as the cut hay dries out.

This urban site poses another problem, which the Trust has yet to overcome. This is the frequent appearance of motorcyclists who tear around the site. The uneven terrain makes Stockwood an attractive place for scramblers, and unfortunately the many entrances that lead from the surrounding housing estates were designed to encourage access rather than to deter motorcycles. It would require the expenditure of thousands of pounds to make the site bike-proof. Even were the funds available, could their use for this purpose be justified? Undoubtedly if this work were to be done we could offer a much more pleasurable experience to the pedestrians who visit the reserve and enjoy its wildlife. No doubt this dilemma will be discussed for several more years.

CLEVEDON COURT WOODS

Clevedon Court's 73 hectares are the largest single block of woodland under the management of the Trust. One of the main reasons for taking on the site was the huge potential it offered for improving the habitats through commercially viable forestry practices. Parts of the reserve are occupied by ancient woodland and are home to Small-leaved Limes, Silver-washed Fritillaries, and carpets of Anemones. The challenge was to encourage such species to spread into the plantations through appropriate management. After several years of survey and negotiation the Trust was about to embark upon its grand plan when along came the storms of January 1990. Freak winds blew down over a thousand trees in a few hours and presented the Trust with a whole new set of management problems. Thankfully the public have a soft spot for trees and a rapidly launched appeal attracted many donations, while the government decided to extend Task Force Trees (TFT), a fund for woodland restoration run through the Countryside Commission, into South-west England. The Trust used this extra funding to appoint a Woodlands Officer to its staff to oversee the management of Clevedon Court and other woodlands.

A revised programme of work began early in 1991. The clearance of the fallen trees was subsidised by TFT, affording the Trust breathing space to find opportunities to sell the timber at a time when markets were virtually saturated. From a landscape of total tree cover appeared large clearings. Whereas the original plantations were composed largely of conifers, Holm Oak and Sycamore, the replacement plantings by TFT were all of native species typical of the local area, trees such as Oak, Ash, Cherry and Small-leaved Lime. These areas may look little more than scrubby wastelands for several years to come, but one day they could hold the atmosphere and interest associated with the ancient wildwoods. As with many large plantations the newly formed gaps in the canopy add valuable diversity in an all too uniform woodland. The increase in woodland edge and shrub cover should benefit birdlife.

Another element of this programme is the creation of a series of open rides and glades across the ridge of Court Hill. Much of this area, known as the Warren because of its previous use for rabbit farming, was planted with trees only in the 1960s. Remnant patches of limestone and acid grassland just hang on where there are gaps in the heightening canopy. These grassy areas hold no rarities but the patches of Perforate St John's Wort and Sheep's Sorrel provide a nice complement to the developing woodland. By opening up these areas and linking them together more viable populations of grassland flowers can be established which should prove attractive to butterflies and other insects and help to set off the ancient earthworks scattered over the hill. As these cleared areas have suffered from a recent history of shade and excessive leaf litter, some will need to be rotavated and seeded with grasses typical of these soils. To ensure that the rides do not revert to woodland a programme of autumn mowing will be introduced.

There is much work to be done. In practice much of the maintenance is carried out by a handful of dedicated volunteers. Situated on the edge of Clevedon the reserve has many visitors, not all of whom behave in a way which is compatible with the site's status. Local people provide the Trust with eyes and ears on the ground. They also clear paths and coppice the ancient Norton's Wood that shoulders the Gordano Valley. Recruiting and supporting such teams of wardens is yet another aspect of the Trust's reserve work.

PLATE 2. Windpump at Weston Moor, July 1984.

WESTON MOOR

Picked out by the windpump sporting the Trust's emblem of a Grey Heron (Plate 2), Weston Moor is a surprisingly rich and diverse reserve. Ditches and reedbeds attract Reed Warblers, the Birch and Alder Carr is carpeted with an array of ferns, the pond is home to dragonflies and bladderwort while an area of fen is the county's only refuge for Heath Dog Violets and Lesser Butterfly Orchids. Perhaps surprisingly two-thirds of the 10·5 hectare reserve consists of an old refuse tip!

Historically management of the reserve has centred on overcoming a catalogue of problems. To compensate for the run-off from the newly constructed M5 motorway the water table in the Gordano Valley was lowered in the 1970s, putting wetland habitats - including Weston Moor - under threat. An enterprising band of volunteers was determined that the reedbed should not be allowed to dry out. In 1981 they found a second-hand windpump which they renovated and erected on the edge of the bed. Water is pumped from one of the boundary rhynes (ditches) and piped into the traditional heart of the reedbed. Although the extra water improved reed growth, time has shown that the pump alone would not maintain the entire original reedbed. In the mid 1980s the Trust, recognising the limitations of the original solution, started to consider alternative approaches. Where the reed growth had become particularly sparse a mowing regime was introduced in the hope of encouraging the spread of fenland plants. A review of the reserve in 1989 suggested that this mowing was having the desired effect, but that the reedbed was still drying out, while the old tip was becoming overgrown as a result of the dying out of the local rabbit population. A radical new approach was needed.

Rather than trying to maintain the original area of reeds it was decided to concentrate on a smaller area that better reflected the capacity of the windpump. The main interest of this habitat was as a breeding haunt of Reed and Sedge Warblers, whose remnant populations were now confined largely to the ditches. It was therefore decided to excavate a series of new ditches within the old reedbed and to create a large pond to act partly as a reservoir. A comprehensive programme of works was agreed and grants were secured from the Nature Conservancy Council and the Worldwide Fund for Nature.

A digger was brought to the site in October 1990 and within days the new features - a large pond on the site of a bracken bed and a series of four ditches - had been created. In order to enhance other areas within the reserve modifications were made to allow grazing to take place. Firstly two ramps were constructed to give cattle access to adjacent ditches as a source of drinking water. A long length of electric fencing was purchased so that grazing stock could be penned into discrete but varying areas, while stiles were constructed to ensure that visitors continued to have access across the reserve. A rigorous programme of scrub removal was implemented in the area of fen meadow to complement the actions of the grazing cattle. Last but not least, a sluice was constructed across one of the boundary ditches in order to maintain a higher water table in the area of the reserve and a better supply of water to the windpump.

We now watch with anticipation to see whether the grazing and other new measures provide the benefits we seek.

CHEW VALLEY LAKE

Virtually ever since the dam was completed in the early 1960s Chew Valley Lake has been recognised as Avon's most important site for birds (Plate 3). The large populations of wildfowl, Great Crested Grebes and Reed Warblers it supports warranted its designation as one of the first Special Protection Areas in Britain.

On the advice of an *ad hoc* committee of local naturalists, on which the BNS was represented, Bristol Water (the lake's owners) designated the southern end of the lake as a nature reserve, but despite this it was clear as long ago as 1969 that some of the lake's bird interest was in decline. Redshank and Whinchat no longer bred, while the numbers of breeding Shoveler and Tufted Duck, nationally significant prior to 1965, were steadily decreasing. Recognising both the local interest in the lake's wildlife and also its huge potential for positive management, AWT set up a Conservation Working Group for the lake in 1982, involving interested persons and organisations such as the BNS. After much deliberation it was agreed that projects could be carried out to try to off-set the recorded declines and to enhance the value of the reserve area in particular. Since then an ambitious programme of conservation projects has included digging ditches within the reedbed, creating a series of permanent pools to counter the effects of fluctuations in lake level, the construction of a public exhibition and associated trails, and the provision of a very popular bird hide within the nature reserve. However, the programme's cornerstone has been the provision of nesting islands for the ducks and other waterbirds.

PLATE 3. Chew Valley Lake open day, April 1987.

Most of the eleven islands have been created in Herriott's Pool, which has the advantage of a nearly constant water level, thus ensuring that islands will remain in being during periods of dry weather. Initially Bristol Water were wary of the concept of conservation management, and early projects were designed so as not to interfere with the basic layout of the pool. Gradually perceptions have changed to the extent that the south-east shoreline of Herriott's Pool as seen today has been largely re-profiled to make it more varied and more attractive to birds. Islands were easily created out of the lake's clay bed using heavy machinery, but making them attractive to nesting ducks has been more problematical.

Research by the RSPB and others indicates that Shoveler, Tufted Duck and many other ducks prefer to nest between tussocks of grass, especially on islands. To establish the right sward, bare new islands have been sown with an appropriate grass seed mixture. However, Coot, Moorhens, ducks and other birds have found the scattered seed to be a handy food source, and their webbed feet have hampered our attempts by compacting the clay as they feed. The main consequence of these activities has been a high incidence of perennial weeds such as docks and thistles which provide poor cover for ground-nesting birds. It is not easy to rectify the situation as midsummer, the best time to deal with these weeds, clashes with the birds' nesting season. A few of the islands have now been abandoned to a rank growth of weeds, while those with a more promising sward are maintained through a continuing management regime. The unwanted plants are checked by spot treatment with herbicides in early spring and again in early autumn, while any bare ground is re-seeded with grass. All the islands are mown during August and

September to prevent the establishment of shrubs and other coarse vegetation, and to encourage grass growth. In 1991 one island was mown again in November, which achieved its intention of attracting grazing Wigeon and geese, thus further encouraging good grass cover.

Have these islands produced the desired effect? Frankly, the increases in duck broods on Herriott's Pool have been fairly modest to date. However, many duck species do now concentrate on the pool in spring, including Shoveler, Teal (which has still not been proved to nest), Pochard and Shelduck, suggesting that the habitat is at least attractive to the target species. Furthermore the pool now attracts a greater variety of birds than previously - the many visiting birdwatchers will at least have appreciated the Spoonbill, Avocet and Pectoral Sandpiper that have graced it in recent years. We must hope that with perseverance we shall be able in the future to reflect on more substantial benefits.

BRANDON HILL, BRISTOL

The management of the Brandon Hill Nature Park has also concentrated on habitat creation (Plate 4). The objectives behind this work, however, have been very different from those at Chew Valley Lake. Brandon Hill Nature Park has been designed to offer a wildlife experience to the urban dweller. Situated less than half a mile from Bristol's City Centre and incorporated into a Victorian park, the nature park is a place where office workers and local residents can taste the countryside and enjoy some of our commoner wildlife. Today there is plenty to explore, with a hay meadow, a developing woodland with glades, a pond, a shrub border, a butterfly garden and a wildlife garden.

All these features have developed since the Trust began this scheme in 1981. Habitat creation was then very much in its infancy, and many of the projects at Brandon Hill have been experimental in nature, providing both successes and failures.

How can a meadow be created where there is only a regularly-mown lawn? Ecological principles would suggest that the nutrient status of the underlying soil should be reduced, so as to reduce the vigour of the established grass. The most effective means of doing this would be to strip off the topsoil and start again - an approach deemed too drastic for a prim and proper Victorian park. It was assumed that taking an annual hay crop would be a suitable alternative, but ten crops later it is evident that this is a slow way of reducing the nutrient status; some areas are still choked with knee-high False Oat Grass! An alternative approach has been to introduce Yellow Rattle into the sward, as this plant is semi-parasitic upon grasses. The second year (1992) has seen the Yellow Rattle well established in some areas, but it has yet to survive in the grassiest parts.

Even though grass vigour has not been entirely conquered, the Trust has had modest success in its attempts to diversify the sward. Initial experiments concentrated on using wild flower seed mixtures but seeding has mostly proved unsuccessful, even where the original turf was first removed. Very few of the species supposedly in a mixture have actually survived when confronted with a competitive situation in a metre square plot on Brandon Hill. Most of these plots are now covered with grasses, Ribwort Plantain, Dandelions and occasionally Ox-eye Daisy! There have been two major attempts at transplanting turf from herb-rich meadows due to disappear under development. Many of the species that

PLATE 4. Habitat creation on Brandon Hill, Bristol.

came in turf dug up from Hawkfield Meadow in 1987 still persist in the Brandon Hill meadow (including Grass Vetchling and Corky-fruited Water Dropwort), but the turves themselves are now typified by a lush growth of rank grass. The most successful technique for introducing wild flowers into this established sward has proved to be to transplant individual pot-grown specimens. Having already gone through the highly competitive phases of germination and establishment these plants seem better able to hold their own. There is the added advantage that gaps can be filled with the most appropriate individual plants, so Betany and Cowslips have tended to be planted in shorter grass than Ox-eye Daisies and Black Knapweed. It is a rare pleasure to be able to explore in the centre of a city a meadow containing fifty different plant species, however artificial it may be!

Brandon Hill, as with other urban reserves, is very much about offering something for people to enjoy. One priority this places on management is that appearance is as important as components. Consequently the edges of all paths are mown, hedges are pruned and the pond weeded - cosmetic touches which help to make wildlife areas more acceptable components of a city park. Interpretation also takes a higher profile at Brandon Hill. Large signs display the lay-out of the nature park, enticing people to explore its nooks and crannies, while a permanent exhibition is housed in the trust's headquarters, next to the main entrance to Brandon Hill from Jacob's

Wells Road. Without the support and understanding of the majority of people, who live in urban areas, our wildlife could not hope to survive.

THE TRUST'S FUTURE INVOLVEMENT IN NATURE RESERVES

Assuming there continues to be an administrative area appropriate for AWT to work in, it seems that managing nature reserves will continue to be a major focus in the Trust's work. County Trusts have traditionally managed reserves of local importance, and have gained much experience and respect by doing so. The main constraint on how many reserves AWT looks after is likely to be the resources it has available with which to carry out the management necessary if a site is to warrant gaining 'nature reserve' status. In the past, Trusts have usually managed to scratch and scrape together whatever they need. However, recent major changes in land use policy have made nature conservation a bona fide form of land use. Increasing amounts of money are being made available for voluntary bodies, and others, to manage land in an environmentally sensitive manner. The best of the schemes launched to date has been Countryside Stewardship, which is administered by the Countryside Commission. It offers land managers annual payments as an incentive to carry out an agreed management regime. Such schemes could offer the likes of AWT a financial incentive to take more land under its wing, thus placing more wildlife sites in the custody of professional conservationists.

While nature conservation may currently be in vogue, so are many other alternative land uses, from organic farming to golf courses. Folly Farm presents the Trust with many of the dilemmas now facing our farmers. Large parts of the farm are of no particular wildlife interest, and the Trust has spent much time considering how best to use this land - the financial implications are a very important factor in the choice of a realistic option. After much deliberation it has been agreed that about one-third of the ordinary pasture should be planted up with woodland. It is hoped that the woods with their associated rides and glades will increase the value of the farm, and will also offer an opportunity to show other landowners how to make the most of a government scheme to diversify farmland with wildlife in mind. There should still be a few acres left to play with when the next appropriate incentive scheme comes along!

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NOTE The above paper was completed during the last days of the author's service as Conservation Officer of the Avon Wildlife Trust (now the Wildlife Trust, Bristol, Bath and Avon), Jacob's Wells Road, Bristol BS8 1DR, immediately before his move to the Wildfowl and Wetlands Trust. He continues to chair the Chew Valley Lake Conservation Committee on a voluntary basis. - *Editor, July 1994.*

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ENGLISH NATURE AND ITS CONSERVATION WORK IN AVON

by R. BRADFORD

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INTRODUCTION

English Nature (The Nature Conservancy Council for England) is the Government body responsible for promoting the conservation of wildlife and natural features in England. It was set up by the Environmental Protection Act 1990 as one of the three new country-based Councils for nature conservation in Britain, replacing the former Nature Conservancy Council (NCC). It receives annual grant-in-aid (currently £32·4 million) from the Department of Environment, which also appoints the Chairman and Members of its governing Council.

The main functions of English Nature (EN) are:

- establishing and managing National Nature Reserves;
- advising Ministers and Government Departments on policies or site-related matters, for or affecting nature conservation;
- providing advice and disseminating knowledge about nature conservation;
- commissioning or supporting relevant research.

It has a number of important duties which include:

- selecting and notifying Sites of Special Scientific Interest (SSSIs) to planning and other authorities, landowners and occupiers;
- advising local authorities on the establishment of Local Nature Reserves (LNRs);
- entering into Management Agreements with the owners or occupiers of SSSIs;
- providing grant-aid towards projects furthering nature conservation on public and private land;
- granting or approving certain licences in connection with wildlife legislation.

Avon is part of EN's South West Region, a large tract of country which includes the counties of Somerset, Dorset, Devon and Cornwall. The Regional Officer and his Deputy have overall responsibility for EN's work in the region and are assisted by specialist staff including land agents, a team of reserve site managers and estate workers, conservation officers and their assistants - many of whom deal with a specific area or subject, as well as administrative and support staff. EN's office for Avon is based at its regional headquarters in Taunton.

This paper sets out to describe EN's (and its predecessor's) recent work in Avon and highlights some of the tasks facing it in the 1990s.

SITE SAFEGUARD

A major part of EN's work is the conservation of important wildlife habitats. In Avon, EN manages two National Nature Reserves, covering 128 hectares. Some of

PLATE 1. Avon Gorge NNR. View from Stokeleigh Camp, Leigh Woods, looking east towards the Clifton Suspension Bridge, July 1987.

this land is owned by EN, the remainder being leased or managed by agreement.

- **Avon Gorge NNR** (Plate 1). Part of the extensive Leigh Woods lying on the south-western side of the Avon Gorge. The woodlands are of ancient origin and contain Pedunculate Oak (*Quercus robur*), Small-leaved Lime (*Tilia cordata*) and Wild Service Tree (*Sorbus torminalis*). Many varieties of Whitebeam have been recorded, including some which are unique to Leigh Woods. The NNR also contains remnant grassland which supports small populations of nationally-rare plants such as Bristol Rock-cress (*Arabis scabra*), Western Spiked-speedwell (*Veronica spicata*);
- **Gordano Valley NNR** (Plate 2). Lies on peat at the head of the Gordano Valley to the south-west of Bristol. It contains wet pasture and meadows, woodlands and rhynes with an outstanding variety of plants and animals. The recent installation of four sluices by English Nature provides a much greater control over local water levels, a critical issue in the management of wetland communities.

In addition to safeguarding a nationally important wildlife resource, the effective management of these Reserves serves two other important functions for EN. The Avon Gorge NNR, on the fringe of Bristol, attracts a large number of visitors each year. By providing leaflets and discrete signs, EN promotes its work in maintaining part of the Gorge for the benefit of the local community and visitors. In the Gordano Valley NNR, EN demonstrates how farming and wildlife can co-operate to maintain the nature conservation interest of these wetland habitats.

PLATE 2. Gordano Valley NNR, looking south, May 1988.

EN encourages other agencies to acquire and manage land for nature conservation. Woodspring District Council, for example, manages a **Local Nature Reserve** at Uphill to the south of Weston-super-Mare. This limestone grassland site is much loved by local people and supports a wide variety of downland flowers and butterflies, including the nationally rare Honewort (*Trinia glauca*). In 1992 Northavon District Council declared a Local Nature Reserve at Wapley, to the south of Yate. This reserve includes two meadows, traditionally cut for hay, and a small woodland of ancient origin known as Wapley Bushes. Bristol, Bath and Avon Councils have all indicated that they would like to establish Local Nature Reserves in the next few years, and Woodspring is currently considering possible LNRs in Portishead and Clevedon.

There are many areas of the countryside, outside nature reserves, which are also important for their wildlife or geology. Those areas which are considered by English Nature to be of national importance are selected for notification as **Sites of Special Scientific Interest** (SSSIs). This involves thorough field surveys, and the application of rigorous scientific criteria to define minimum standards of scientific interest and nature conservation value. Once sites are approved by English Nature's Council, they are notified to the Secretary of State for the Environment, local authorities and landowners and occupiers. Information about the SSSIs is also sent to a wide range of other organizations whose activities may affect their scientific interest.

There are currently 71 SSSIs in Avon (Figure 1), consisting of sites of biological and/or geological interest, ranging in size from a fraction of a hectare up to several thousand hectares. These SSSIs cover approximately 6,820 hectares or 5% of Avon's land surface. However, the Severn Estuary SSSI accounts for *c*.4,446 ha of

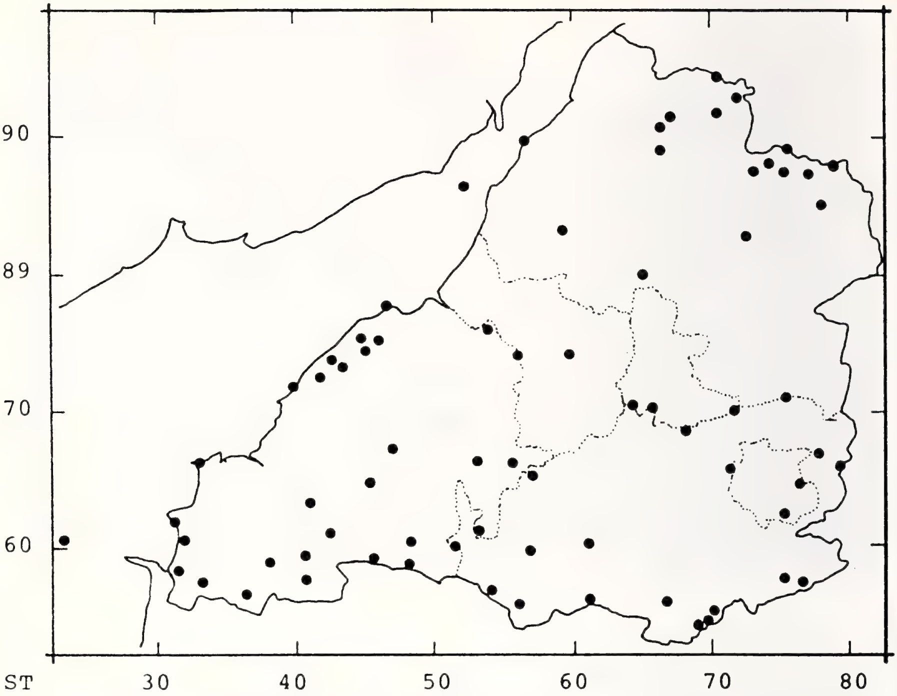

FIGURE 1. Sites of Special Scientific Interest in Avon (showing District Council boundaries: Bristol, Kingswood, Bath, Woodspring, Northavon, Wansdyke).

this area, and if this site is taken out of the figures, the percentage cover falls to 1.7% of the county area. There are some 3,700 SSSIs in England covering approximately 816,000 ha or 6% of the land surface.

Whilst the SSSIs may cover only a small proportion of Avon they contain a remarkably wide range of nature conservation interests. The two smallest sites, at Durdham Down in Bristol and at Hinton Charterhouse are both less than one hectare in size. The former contains a fissure deposit in Clifton Down Limestone whilst the latter supports a small population of a nationally rare plant. In contrast, the Lower Woods complex at Wickwar (280 ha) and Chew Valley Lake (565 ha) are much larger and biologically more diverse.

Most biological SSSIs have been selected and notified because they are particularly good examples of the various habitat types present in the county. The best examples of Avon's woods, unimproved grasslands, wetlands and coastal habitats are SSSIs. Many of these sites were identified as being important for wildlife following county-wide habitat surveys undertaken by our predecessor, the NCC, the Avon Wildlife Trust, Avon County Council and, more recently, by EN itself. A few sites have been notified for the nationally rare plants they contain.

Avon is an important area for geological study and research, having a wide range of rock types from many geological periods. The most important sites, identified

PLATE 3. Severn Estuary SSSI, looking north-west to Sudbrook from Severn Beach, July 1989.

as part of EN's national **Geological Conservation Review** and ranging from the cliffs at Middle Hope, Portishead and Aust to small man-made exposures in quarries and railway cuttings, have been notified as SSSIs. This Review has identified a further six possible SSSIs on account of their Pleistocene interest, sites which English Nature will be notifying in due course.

It is the Government's stated intention to recognize the international importance of the **Severn Estuary** (Plate 3), by designating it as a Wetland of International Importance (under the Ramsar Convention) and as a Special Protection Area under the European Community's Directive on the Conservation of Wild Birds. Whilst EN and the Joint Nature Conservation Committee advise Government on suitable sites for recognition under international conventions or law, the final decision for such designation rests with the Government.

Most of EN's resources in Avon are committed to safeguarding these designated sites. The process of identifying and notifying SSSIs is necessarily long and complex, often taking 18-36 months to complete. EN staff discuss the notification process with landowners and occupiers, recording the way in which the land has been managed in the past and may be looked after in the future. These early discussions are important, in order that a trusting and working partnership can develop to the benefit of both parties.

The notification of land as SSSI has three important functions:

- it recognizes that some areas contain features of "special" wildlife or geological interest which are not found in other areas;
- it provides a mechanism whereby EN can advise on the conservation management of our most important natural heritage;
- it requires consultation with EN over operations which may damage or destroy the features of special interest.

The provision of advice on the suitable management of SSSIs in order to safeguard their nature conservation interest is a vital part of EN's work. This is particularly important in today's agricultural market of falling incomes and an uncertain future. Many grassland SSSIs are, by their very nature, of low agricultural productivity or are peripheral to the main farm holding. In the current uncertainty in the farming industry, it is becoming increasingly apparent that many SSSIs on agricultural land are not receiving the management which is essential to maintain their nature conservation interest. One of EN's greatest problems at present is to encourage the adequate grazing of grassland SSSIs of low agricultural value.

The recent introduction of EN's **"Wildlife Enhancement Scheme"** and the Countryside Commission's "Countryside Stewardship Scheme" may help to resolve some of these problems. The former is currently under trial on the Pevensey Levels in East Sussex and the Culm Grasslands of Devon and Cornwall. The "Countryside Stewardship Scheme" is being applied to six landscape types across the country: uplands, lowland heaths, limestone grasslands, coastal areas, watersides and historic landscapes. Both these schemes are voluntary, but can provide annual payments to land managers, who are required in return to undertake management prescriptions which are sympathetic to the maintenance and enhancement of both the landscape and nature conservation interests of the area.

ENGLISH NATURE'S ROLE IN THE WIDER ENVIRONMENT

In Avon, NNRs and SSSIs, representing the areas of highest conservation value, account for approximately 5% of the land area. EN is also concerned with the conservation of wildlife outside these designated areas, since this represents the major proportion of our wildlife resource and is more accessible to most people. Furthermore, the special sites cannot retain their interest if left in ecological isolation. EN's efforts in the wider environment are directed to helping others and influencing policy and action through advice and liaison.

The majority of EN's work in the wider environment is based on its statutory duties under the various Town and Country Planning Acts. **Structure and Local Plans** are targets for a high nature conservation input and this is now paying dividends. A recent publication "In partnership with the Countryside Commission" (Nature Conservancy Council and Countryside Commission, 1990) sets out guidance on the production of environmentally-led forward plans which should be particularly valuable to those drawing up the new District-wide Plans.

By statute, EN has to be consulted over all **Environmental Statements** prepared under the 1988 Regulations. Over 20 of these Statements have been produced in Avon during the years these Regulations have been in force. The subjects of these Statements are very variable, ranging from proposed power stations to football stadiums, landfill sites to road schemes. The quality of the Statements also varies but on each occasion EN seeks to advise those who are making the decision on the proposal as to the accuracy, validity and completeness of the Assessment and Statement submitted.

The Environmental Protection Act 1990 has given EN new duties to comment on aerial emissions from certain industrial processes. This work is entirely new to EN and it will take some time for staff to develop the knowledge and expertise to respond constructively to such consultations.

In all its advisory work on the wider environment EN promotes the concept of **"sustainable development"**. Unfortunately this term suffers from many different interpretations. In this case the key concept is that development should not reduce the County's or District's wildlife resource any further. If the development is considered to be of over-riding importance then adequate compensation or mitigation measures should be provided to ensure that there is no net loss of wildlife arising from the development.

EN cannot work in isolation on safeguarding the nature conservation interest in the wider environment. It is very dependent on partnerships with other groups and bodies, such as local authorities, the National Rivers Authority, the Avon Wildlife Trust and the Farming and Wildlife Advisory Group, to cover the enormous breadth of work necessary to safeguard the county's wildlife resource.

These partnerships are now being developed through a variety of area- or topic-based strategies. In April 1991 EN published the **"Greater Bristol Nature Conservation Strategy"** on behalf of five local authorities, Bristol Development Corporation, Avon Wildlife Trust, Bristol Avon Groundwork Trust and the Countryside Commission. The Strategy sets out policies for the protection and management of sites of nature conservation interest. It encourages public access to, and the enjoyment of, Bristol's wildlife resource, and seeks better co-operation between the various local authorities, organizations and conservation groups working within the Strategy area. The Strategy is now being implemented by the Avon Wildlife Trust/Bristol City Council's "Bristol Wildlife Officer", with substantial grant-aid from English Nature.

The **"Northavon Landscape and Conservation Strategy"** was published in March 1992 by Northavon District Council and Avon Wildlife Trust, with financial support from EN and the Countryside Commission. Similar strategies are being developed for Wansdyke and Woodspring by the Trust with assistance from EN.

As part of its work on the **Avon Levels and Moors** in 1992, EN, in consultation with the South Gloucestershire Internal Drainage Board, undertook a botanical survey of selected watercourses which are managed by the IDB. The subsequent survey report (Pollock, 1992) identified the watercourses of greatest wildlife interest in the Board's area, and recommended management techniques which would maintain or enhance their interest. EN hopes to work in a similar way with the North Somerset and West Mendip IDBs over the next few years, as these Boards are responsible for the management of a very significant part of the important wildlife resource recently identified on the Avon Levels and Moors.

SPECIES PROTECTION

EN has three statutory duties relating to the conservation of individual species:

- to advise Government as to which species deserve special protection in the Schedules of the Wildlife and Countryside Act 1981;
- to issue licences for activities otherwise prohibited under the legislation;
- to advise on works which may disturb, obstruct or destroy bat roosts.

The first two duties are carried out by EN's science and licensing branches from our headquarters in Peterborough, in consultation with regional staff. The third duty is undertaken by local scientific staff.

All British species of **bat** are protected by law. Of the 14 bat species breeding regularly in Britain, 12 have now been recorded in Avon with breeding confirmed for six of these (Jones & Jayne, 1988). The majority of EN's work on bats follows from its duty to advise on works which may affect bat roosts. This generates some 40-50 enquiries a year from building firms, timber treatment companies and householders wishing to undertake work in roof spaces where bats are known to roost. EN relies heavily on the work of the Avon Bat Group carrying out roost visits and promoting the conservation of bats to the general public.

The **Badger** (*Meles meles*) has been protected from wilful killing, injury and cruel ill-treatment since 1973, but the recent Protection of Badgers Act 1992 extended that protection to the badger sett itself. This new Act makes it an offence to "interfere" with a sett, which includes obstructing access to any entrances, damage or destruction of a sett. Provision is made for such interference to be done under licence from EN or the Ministry of Agriculture, Fisheries & Food.

EN is charged with administering the licence necessary to interfere with a badger sett which lies in the way of development with valid planning consent. Before issuing any licences EN will ensure that the welfare of the badgers using the sett is fully taken into account. No licences will be issued if there is a risk of injury, death or cruel ill-treatment of badgers by interfering with a sett. Avon supports a high density of badgers and there are frequent conflicts of interest between this protected species and the need for new development and roads. EN's advisory work on badgers in Avon is likely to increase steadily in future as a result of the new legislation, and it will continue to rely heavily on the Avon Badger Group for up-to-date survey information and on recognizing potential conflicts between badgers and development which would otherwise be missed.

Other fully protected animals occurring in Avon are Dormouse (*Muscardinus avellanarius*), Great Crested Newt (*Triturus cristatus*) and, hopefully, Otter (*Lutra lutra*). Whilst EN is not legally required to provide advice on these species, it will seek whenever appropriate to promote the conservation of habitats used by them. Advisory work regarding **Great Crested Newts** usually arises from development proposals which might lead to the loss of their aquatic habitat. In these situations EN seeks to encourage the developer to retain the ponds and surrounding habitat in the development, and make provision for their subsequent management to support future populations of the Newts.

Advisory work on the protection of **Dormice** (*Muscardinus avellanarius*) is largely confined to SSSIs, as EN is rarely consulted over woodland management in the wider countryside. The **Otter** appears to be re-colonizing some of Avon's rivers and if this trend continues EN is likely to have a rôle in providing advice on safeguarding the habitats of this elusive species.

Three specially protected birds are known to breed in Avon: Peregrine (*Falco peregrinus*), Kingfisher (*Alcedo atthis*) and Hobby (*Falco subbuteo*). EN is directly involved in the conservation of the former due to the close proximity of one of its breeding sites to the Avon Gorge NNR.

Avon supports populations of four specially protected plants: the Field Eryngo (*Eryngo campestre*), Brown Galingale (*Cyperus fuscus*), Cheddar Pink (*Dianthus gratianopolitanus*) and a horsetail (*Equisetum ramossissimum*). The sites involved have now been notified as SSSIs and EN encourages their management so as to maintain or strengthen these populations.

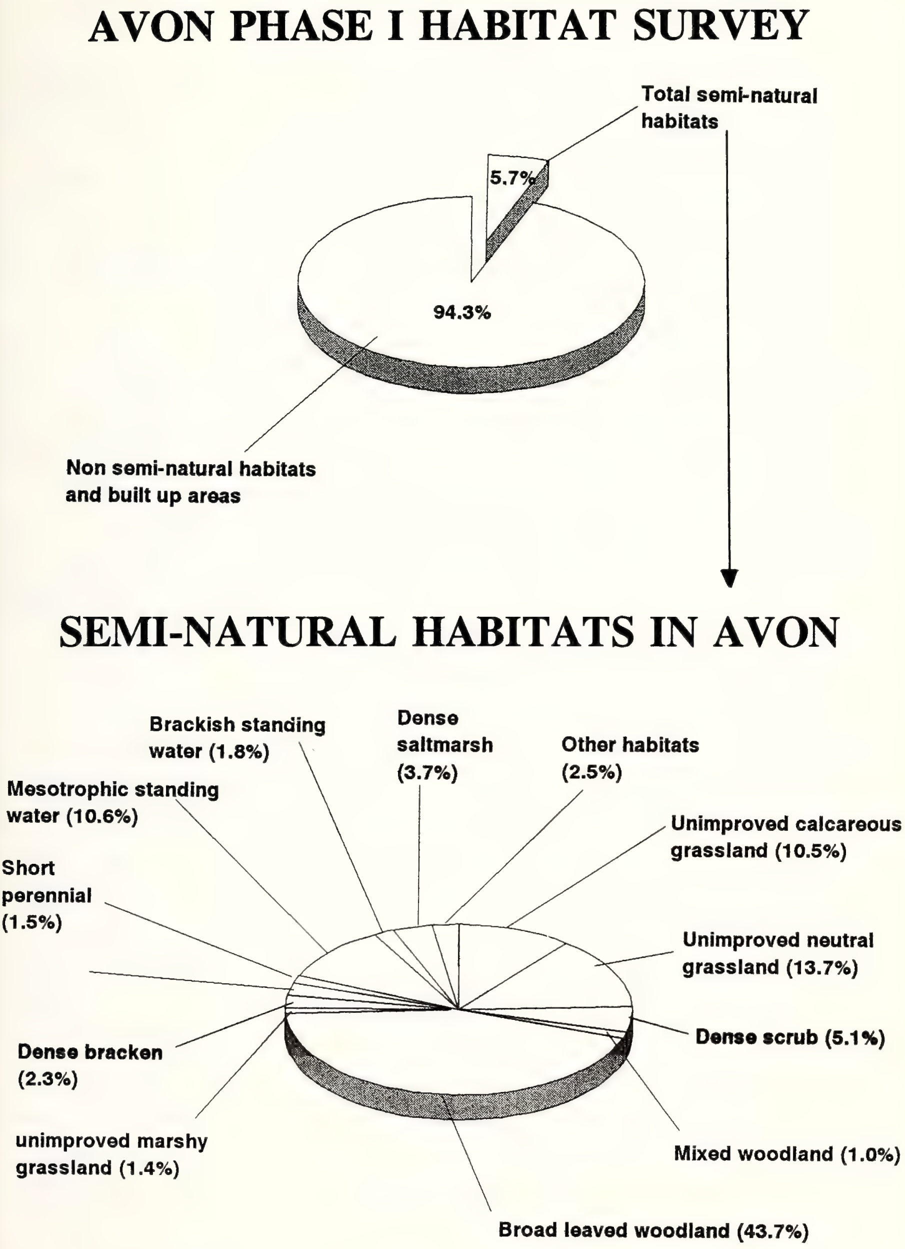

FIGURE 2. Results of a land use and habitat survey of Avon, taken from Nature Conservancy Council (1990).

SURVEY AND MONITORING

EN's scientific work is the essential base from which it develops policies and programmes for practical nature conservation. In addition to carrying out detailed surveys of existing and possible SSSIs, the Nature Conservancy Council, and more recently EN, has undertaken several strategic wildlife surveys in Avon since 1987.

The **Avon Phase 1 Survey** mapped the entire county, between 1986 and 1989, in terms of land-use and semi-natural habitats (Figure 2). The areas of semi-natural habitats were measured from the survey maps and were collated by 5km square, by district and for the whole county to provide an overall assessment of the extent of these habitats. The survey was the first of its kind to cover systematically and classify the entire land area of the county.

The Phase 1 survey report (Nature Conservancy Council, 1990) contains the most complete and detailed breakdown of habitat areas achieved so far in Avon. The survey report and habitat maps have been provided to local authorities, the Avon Wildlife Trust and the Bristol/Avon Record Centre. The information gathered should be of particular value to local authorities in formulating their policies for the future protection and enhancement of areas of nature conservation importance.

In 1990 Nature Conservancy Council commissioned a review of the status of the nationally-rare plants occurring in Avon. This review (Nature Conservancy Council, 1991) involved checking current and historical records of populations of these species, and providing up-to-date advice on the status and management requirements of the remaining populations. The results of the current Botanical Society of the British Isles' review of nationally scarce plants, and the work of the Avon Flora Project, are eagerly awaited as they will essentially complement NCC's rare plant survey.

More recently EN has turned its survey resources towards the **Avon Levels and Moors**. In 1991-92 over 1,400 ditches from the peat moors of Gordano Valley, Nailsea and Kenn Moors, and from the clay levels around Kingston Seymour, Banwell and Puxton, were surveyed for their botanical interest, complemented by an invertebrate survey of 70 ditches over the same geographical area (Figure 3), which recorded the presence and abundance of water beetles, molluscs, dragonflies and damselflies. The survey report (Pollock, Bradford & Christian, 1992) concluded that the Gordano Valley, Tickenham, Nailsea and Kenn Moors, South Wemberham-Cadbury Farm and Puxton Moor supported a ditch flora and fauna as rich as similar parts of the Gwent Levels SSSIs and the Somerset Levels and Moors SSSIs.

In 1992, EN started work on the compilation of an inventory of the remaining unimproved grasslands of the Cotswolds in Avon. To date this work has focused on the Cotswold scarp around Hawkesbury and Doynton and the hills and valleys to the south of Bath. Only 184 hectares of unimproved grassland have been recorded so far, from 31 sites. The provisional **Cotswold Grassland Inventory** (Twiggs & Rooney, 1992) concluded that in many areas the unimproved grassland is now restricted to steep banks, where it has not been possible to improve the ground agriculturally by cultivation, reseeding and the use of artificial fertilizers. Many of these areas appear to be of peripheral value to the main farm holding, in which case they may not receive the management necessary to sustain their conservation value.

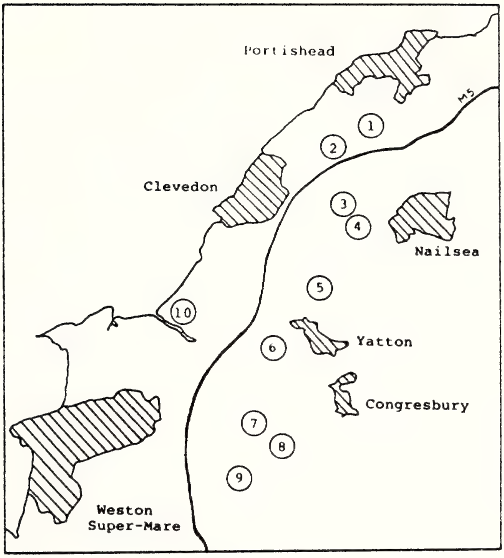

FIGURE 3. Avon Levels and Moors. Rhynes and ditches of high nature conservation interest identified by Pollock, Bradford & Christian (1992). 1, Clapton Moor; 2, Gordano Valley SSSI; 3, Tickenham Moor; 4, Nailsea Moor; 5, Kenn Moor; 6, Biddle Street, Yatton; 7, Puxton Moor; 8, Carditch Rhyne, Congresbury; 9, Middle Moor Rhyne, Banwell; 10, Kingston Seymour.

In addition to identifying the remaining extent of this important wildlife resource, the inventory should assist MAFF to establish an appropriate southern boundary to the proposed Cotswold Environmentally Sensitive Area. It should also assist the Countryside Commission in considering applications for their Countryside Stewardship schemes in the Cotswolds.

GRANT AID

EN has the power to give grants in aid of work which is of benefit to nature conservation and people's enjoyment of our natural heritage. Whilst grant-aid is only a small part of EN's budget (£0·85 million in 1992/93), it is often used to pump-prime schemes which would otherwise not take place. In recent years, EN has financially supported schemes in Avon such as:

- Nature Conservation Grant Schemes
  - Bristol Wildlife Officer
  - Wansdyke Landscape and Nature Conservation Strategy
  - Preparation of management plans for nature reserves.
- Community Action for Wildlife Scheme
  - Hartcliffe Environmental Action Group - activity days
  - Thornbury Group of the Avon Wildlife Trust - restoration of mediaeval fish ponds
  - Northavon District Council - management and interpretation facilities at
  - Wapley LNR and Huckford Quarry

  - Avon Wildlife Trust - tree festival
  - Weston-super-Mare Civic Society - tree planting to create a green gateway to the town.

- School Nature Area Schemes
  - every year 6-8 schools in Avon received £200-£500 each towards improvements to their school grounds which are of benefit to nature conservation.

ENGLISH NATURE'S FUTURE WORK

Looking to the future, the safeguard and conservation management of land of SSSI quality will continue to be the highest priority for EN's resources. It will seek to ensure that nature reserves and SSSIs retain the features for which they are important, by means of monitoring, the preparation and implementation of management plans, and by close liaison with owners and occupiers. Additional SSSIs are possible as a result of the completion of survey work on the Avon Levels and Moors, on the Cotswold Grasslands and the Geological Conservation Review.

EN is particularly keen to develop its role in the wider environment through strengthened liaison and partnerships with the many authorities, bodies and interest groups influencing the management of the urban and rural environment. Targets will include:

- **District Local Plans** - ensuring these are environmentally-led and support a firm commitment to sustainable development;
- **Management of Watercourses and Wetlands** - encouraging the sympathetic management and enhancement of rivers, rhynes and ditches in the county's remaining wetlands, through partnerships with the National Rivers Authority, Internal Drainage Boards and local authorities;
- **The Coastal Environment** - through the implementation of English Nature's national campaign for a Living Coastline. This includes encouraging a strategic approach to coastal defence systems, including the consideration of coastal retreat in appropriate locations;
- **Implementation of nature conservation strategies** - for Greater Bristol, Gordano, Bath and Northavon. Supporting the preparation of strategies for Wansdyke and Woodspring.

The resources available for nature conservation work in Avon have increased substantially in recent years. However, they will always remain less than adequate to meet all the aspirations of EN and its partners in nature conservation. This review of EN's future work has revealed an increasing workload across a broad range of targets. It is unlikely that EN's staff resources for Avon will increase in the near future and invariably difficult decisions will need to be made as to the priorities for these limited resources. It will be important to ensure that the resources available are not spread so thinly that they undermine the quality of service and advice on nature conservation that EN provides.

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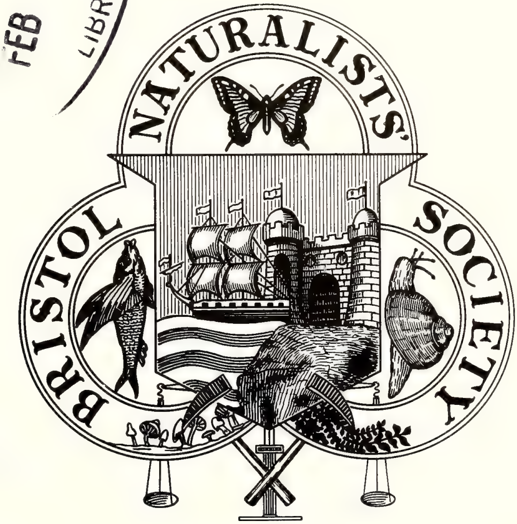
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Ornithological	President:	B.M.J. Gray
	Hon. Secretary & Treasurer:	R. G. Holmes

Other Members of Council:

G. R. Best
Dr G. Jones
Miss A. Heckels
Dr N. Malcolm
Mrs H. Titchen
D. P. C. Trump
D. A. Wilson

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CONTENTS

GENERAL & SECTIONAL PROCEEDINGS

Council, 1993 2
Report of Council, 1993 4
Minutes of Special General Meeting, 2 December 1993 .. 5
General Meetings, 1993 5
General Field Meetings, 1993 6
Report of the Geological Section, 1993 7
Report of the Ornithological Section, 1993 7
Report of the Botanical Section, 1993 8
Library Report, 1993 9
Statement of accounts for the year ended 31 December 1993 10
Past Presidents 12

BRISTOL BIOTA

Avon & District Invertebrate Report, 1993 13
Instructions to Authors 22
Avon Mammal Report, 1993 23
Bristol Botany in 1993 35

ORIGINAL PAPERS

Lower Wetmoor Wood - an introduction, by M. H. Martin & S. M. Taylor 47

The oaks of Lower Wetmoor Wood (I), by S. M. Taylor & M. V. Taylor 59

The effects of coppicing on the vegetation of the field and ground layers of an ancient woodland, Lower Wetmoor Wood, by M. H. Martin & R. M. Martin. 73

REPORT OF COUNCIL, 1993

Membership at the end of 1993 stood at 575, a slight fall from the previous year-end. At the Annual General Meeting in January Mr D. A. Wilson was elected President in succession to Mr R. G. Symes, and the Officers and Members of Council were elected. Council met eight times during the year. The usual ten issues of the *Bulletin* appeared, under the editorship of Mr and Mrs R. G. Symes; we are grateful for their hard work, and for the steady development of the appearance and content of this main link with our members. The Society's *Proceedings* for 1991 also appeared, under the capable editorship of Dr Peter Crowther, to whom we also express our gratitude. Members also received *The Swallow*, as the Society is a subscribing member of the British Trust for Ornithology, and the *Avon Bird Report* for 1992, which is published by a consortium of the Society and Bristol Ornithological Club.

During the year there were six lectures and eight field meetings of general interest as well as 17 lectures and 43 field meetings organised by the Sections. A brief Special General Meeting in December approved some alterations to the Society's Rules, which were necessary for compliance with the requirements of the Charities Act 1992. A special occasion was a conducted tour of the BBC's Victorian Garden near Hungerford, which was enjoyed by over 50 members and guests. More than 70 members and friends attended the annual Buffet Supper, where there was not only good food and company but also a talk by Keith and Geraldine Taylor, who had recently set up the "Friends of the Bristol Downs". Members received details of the annual Study Tour of the South-Western Naturalists' Union, which is an association of 38 societies, including ourselves.

Many members of Council contributed as volunteers and advisors in their own specialist fields, e.g. in the Severn Estuary Conservation Group, in work on bats, butterflies, moths, birds, mammals, the Avon Flora project and English Nature's "Dawn to Dusk" day in Leigh Woods and the Avon Gorge. It is good to record the formation of a Mammal Group during the year, which Council hopes will in time become a re-born Mammal Section.

Special mention must be made of several Council members who are standing down this year after making great contributions to the running of the Society and to its standing: Miss S. Garden, who as *Bulletin* Distribution Secretary organised the distribution of some 500 copies ten times a year; Miss F. Gravestock, who kept Council informed of events in the conservation movement; and Dr R. Bradshaw as Chairman of the Publications Committee. Mrs A. F. Hollowell and Mr S. M. Taylor, two Past Presidents and longstanding Council members, were made Honorary Members at the Annual General Meeting in January, in recognition of many years' service to the Society.

Grants were made from our Conservation Fund to the Avon Wildlife Trust's Folly Farm Appeal, and from the Hector Hockey Memorial Fund towards the expenses of a long-term butterfly monitoring project, a study of hedgerow history, a light trap for the Avon Moth Group, and the publication of a paper in the 1992 *Proceedings*.

Council records with regret the deaths during the year of the following members: Prof. R. W. G. Carter, Mr H. Eales, Dr C. F. Gozna, Miss M. I. Jefferies, Mrs Betty Jones, Miss D. Nicholls, Mr R. P. Scase, Mr E. Storey and Dr F. L. Vanderplank. Council also notes with regret the deaths of two distinguished former members, Professors I. S. Loupekine and E. W. Yemm.

Igor Loupekine was born in Egypt of Russian emigré parents. He obtained a First Class Honours degree in Geology at Bristol in 1943 and was appointed Assistant Lecturer shortly afterwards, and Lecturer in 1947. He moved in 1957 to Nairobi as Senior Lecturer in Geology at the Royal Technical College of East Africa, becoming Professor in 1960 and retiring in 1985. While in Bristol he was a keen member of our Geological Section and served for 13 years as its Honorary Secretary. In 1958 he was one of the two founders of the Geological Club of Nairobi, with a programme of lectures and excursions modelled on our own. This became very popular, and some of its members made important discoveries in the region.

Professor E. W. Yemm was Head of the Botany Department at the University of Bristol from 1955 to 1974, and was a member of the Society for almost all that time, serving for a long period as Chairman of our Publications Committee. For a further note, see Professor Willis's introduction to *Bristol Botany in 1993* in this issue.

SYLVIA KELLY, *Hon. Secretary.*

MINUTES OF SPECIAL GENERAL MEETING

held at Victoria Church Hall on 2 December 1993.

The President, Mr D. A. Wilson, was in the Chair and 50 members were present.

The Hon. Treasurer, Mr S. M. Taylor, explained that in order to conform to the Charity Act 1992 certain changes to the Society's Rules were necessary. He proposed that:

a) Rule 7(a) be amended by deletion of the words, "an auditor"
b) Rule 7(d) be amended to read, "Each Past President who has expressly indicated in writing a wish to remain an active member of Council."
c) Rule 8(d) be re-numbered 8(e).
d) A new Rule 8(d) be inserted, reading "To appoint an Auditor, who may be a member of the Society but shall not be a member of Council."

The proposal was seconded by the Hon. Secretary, and approved by all those present.

SYLVIA KELLY, *Hon. Secretary.*

GENERAL MEETINGS, 1993

16 Jan.	Annual General Meeting & Presidential Address - "Badgers - a grey case for conservation", by Mr R. G. Symes.
6 Feb.	"Ladybirds and other insects", by Mr R. J. Barnett.
6 Mar.	"The Great Barrier Reef: on the ground, in the sky, under the sea", by Mr R. Freeman.
2 Apr.	Annual Buffet Supper. "Wildlife on the Downs", by Mr K. Taylor.
7 Oct.	"Threatened wildlife", by Dr W. Cresswell.
1 Nov.	"Forest habitats in the Amazon", by Mr N. Wray. Joint meeting with Botanical Section.

2 Dec. Special General Meeting and "Wildlife and environmentally sensitive farming on the Somerset Levels", by Mr D. Glaves.

SYLVIA KELLY, *Hon. Secretary.*

GENERAL FIELD MEETINGS, 1993

27 Mar. Mr D. A. Cullen. Morning meeting at Chew Valley Lake. Some winter duck were still present, and early Swallows and Sand Martins were seen, and in nearby woodland were early spring flowers and woodland birds.

9 Apr. Miss S. Garden. Exmoor: walk from Dulverton up River Barle and back over Court Down. Early spring flora, woodland birds, excellent views.

8 May Miss J. Vine and Miss M. Morris. Hinton Charterhouse and Wellow. Walk on a fine spring day, through flower-rich meadows and woods, and by a lane to Wellow Brook. Many spring flowers seen, including Fly Orchid. Bird song included Nightingale.

5 Jun. Miss R. C. Lee. Haldon Forest, near Exeter, on a perfect summer day. Fine views, but not many birds seen from the Bird of Prey Viewing Point. Afternoon guided walk through the forest, with a number of butterflies seen.

17 Jul. Miss R. C. Lee. Morning visit to Cirencester Park, noting fine trees. Afternoon walk along a disused canal and old railway track near South Cerney. Many flowers, also butterflies and damsel flies.

7 Aug. Miss R. C. Lee. Neroche Forest, near Taunton. Walk through forest and along farm tracks and lanes. Fine views, many flowers and butterflies.

8 Sep. Miss R. C. Lee. BBC Victorian Garden at Chilton Foliat near Hungerford. Visit to which Friends of the University Botanic Garden were invited. A A very informative and amusing tour, with Head Gardener Harry Dodson and BBC officials as guides.

11 Sep. Mr D. A. Cullen. Powderham and Dawlish Warren. Waders, gulls and terns. Good view of Arctic Skua mobbing a gull, A Little Egret seen.

23 Oct. Miss S. McCarthy. Painswick area. On a lovely October day, walk through fields and old orchards from Edge to Painswick, then guided tour round Painswick House rococo garden.

6 Nov. Miss R. C. Lee. New Forest. Return visit to a circular walk from Beaulieu Road Station, through Bishop's Purlieu. Autumn colour still good; birds, flowers and fungi.

RACHEL C. LEE, *Hon. Secretary, Field Committee.*

REPORT OF THE GEOLOGICAL SECTION , 1993

At the annual general meeting held on 20 January, the following were elected: President - Dr M. J. Simms; Hon. Secretary - Dr P. R. Crowther; Hon. Field Secretary - Mr S. C. Carpenter; Treasurer - Mr V. D. Dennison; Committee - Dr M. J. Benton, Mr D. Cope, Mrs M. Poolman, Mr D. A. Wilson.

GENERAL & SECTIONAL PROCEEDINGS

The following indoor meetings were held:

20 Jan.	Annual General Meeting and Presidential Address, "Hock Cliff - Geology between the tides", by Mr D. A. Wilson.
17 Feb.	"The Rhaetian fauna of South-West England", by Dr G. Storrs.
17 Mar.	"The Eye of Faith", by Dr R. Bradshaw.
20 Oct.	"Cotswold dinosaurs from a Jurassic pond", by Miss S. Metcalfe.
10 Nov.	"The Evolution of Wales", by Dr M. J. Bassett.
15 Dec.	Members' Evening.

The following field meetings were held, under the leadership of those shown:

14 Mar.	Monk's Park Stone Mine, Corsham, near Bath. Combined meeting with Bath Geological Society.
25 Apr.	Triassic sites of the Butcombe - Nempnett Thrubwell area of south Avon. Dr M. J. Simms.
27 Jun.	Lower Jurassic rocks of the Radstock district. Mr A. Bentley & Mr S. C. Carpenter.
7 Aug.	The University Museum, Oxford. Mr P. Powell.
9 Oct.	Writhlington Geological Nature Reserve, Avon. Dr E. A. Jarzembowski.
6 Nov.	Geologists' Association Reunion, London. Combined meeting with Bath Geological Society.

PETER R. CROWTHER, *Hon. Secretary.*

REPORT OF THE ORNITHOLOGICAL SECTION, 1993

At the 69th Annual General Meeting on 20 January, the President, Mr B. M. J. Gray and the Hon. Secretary and Treasurer, Mr R. G. Holmes, were re-elected. Dr H. E. Rose retired from the Committee by rotation, and Mr K. Taylor was elected. The following indoor meetings were held:

20 Jan.	Annual General Meeting and Presidential Address, "A Swan around the Docks: a guide to the wetlands of Central Bristol", by Mr B. M. J. Gray.
12 Feb.	"Birds of Sri Lanka", by Mr P. James.
10 Mar.	"Birds of Wiltshire", by Mr J. Govett.
13 Oct.	"Birds of Australia", by Dr P. Basterfield.
12 Nov.	"Have hide, will travel", by Mr M. Mockler.
17 Dec.	"Bird Migration", by Prof. C. Pennycuick.

There were 21 field meetings, only a few marred by poor weather. Of special note was the turnout of over 40 for the visit to Slimbridge in January, and in July the adventurous visit to Steep Holm by 16 intrepid members in decidedly choppy conditions.

Following pilot work in 1992, 25 one-km squares were surveyed for the BTO's new Breeding Bird Survey. Support was given for the national Waders of Estuaries and Roosting Gulls surveys and long-running Heronry Census. Fieldwork also included our Bunting Survey and Woodpeckers and Woodland Birds Survey, in their second and third years respectively. A new Song Thrush Survey was started, and the Birds in Gardens Survey organised by R. L. Bland completed its 20th year.

RICHARD HOLMES, *Hon. Secretary.*

REPORT OF THE BOTANICAL SECTION, 1993

At the Annual General Meeting on 6 January Mr A. C. Titchen and Mr A. G. Smith were re-elected as Section President and Honorary Secretary respectively.

The following indoor meetings were held:

6 Jan.	Annual General Meeting and Members' Evening.
9 Feb.	"Fungi and trees - a panoply of relationships", by Dr A. M. D. Rayner.
3 Mar.	"British Orchids", by Miss C. Saunders.
5 Oct.	"A Naturalist in the southern Pyrenees", by Mrs P. M. Hill-Cottingham.
4 Nov.	Joint General / Botanical Section Lecture.
14 Dec.	Members' Evening - slides and other items.

The following field meetings were held, under the leadership of those shown:

25 Apr.	Expury Gardens. Mr A. G. Smith.
14 Mar.	Bryophytes, North Nibley area. Mr P. Martin.
5 May	Leigh Woods. Mr P. J. M. Nethercott.
16 May	Sand Point. Mr & Mrs M. A. R. Kitchen.
26 May	Kewstoke and Worle (evening meeting). Mr M. Evans.
10 Jun.	Street trees in Bristol (evening meeting). Mr A. C. Titchen.
19 Jun.	Braunton Burrows. Mrs H. Titchen & Dr N. Malcolm.
1 Jul.	Walton Manor, Walton-in-Gordano. Mr & Mrs A. C. Titchen.
10 Jul.	Wick Rocks. Mr P. J. M. Nethercott.
18 Jul.	Abbotsbury Sub-tropical Gardens. Mr A. C. Titchen.
27 Jul.	Frome Valley, Frenchay (evening meeting). Mr A. G. Smith.
8 Aug.	Blagdon Lake. Miss P. Pockson.
5 Sep.	Batsford Park arboretum: autumn fruits. Mr A. C. Titchen.
19 Sep.	Stockhill Woods, Priddy: fungus foray. Mr J. Keylock.

A. G. SMITH, *Hon. Secretary.*

LIBRARY REPORT, 1993

The post of Hon. Librarian remained vacant. Mrs A. F. Hollowell stood down as Chairman of the Library Committee, but was prevailed on to become its Honorary Secretary. Mr R. G. Symes was elected Chairman, and he expressed the Committee's appreciation of Mrs Hollowell's guidance over many years.

Members of the Committee staffed the Library at its normal opening times of 1.15 - 1.45 pm on Wednesdays and 10.15 am - 12 noon on Saturdays. During the year 221 visits were paid by 34 members and members of the Museum staff, who borrowed a total of 180 items. Twelve books were purchased, and over 70 books and journals were presented to the Library for which we are indebted to Dr L. C. Frost, Miss I. F. Gravestock, Mrs A. F. Hollowell, Mrs P. M. Millman, Mr P. J. M. Nethercott, Dr H. A. Osmaston, Dr H. E. Rose, Mr R. G. Symes, Mr S. M. Taylor, Mr D. A. Wilson and the estates of Mr L. T. Jones and Dr J. Mattocks. Currently 31 journals are received on subscription and 40 by exchange.

The Library Committee met on five occasions, and three working parties were arranged. The work done included resiting part of the library stock to take advantage of new shelving, rationalization of subject positions and the application of new shelf labels. Unwanted foreign journals were sold, and a surplus cupboard was disposed of. Contributions are still sought for the Library's file of references to local material.

The Society thanks Mrs Hilary McGowan. Divisional Director (Museums and Heritage), Leisure Services, Bristol City Council, for continued use of the Library Room and for assistance given to members during the year by Museum staff.

R. G. SYMES, *Chairman, Library Committee.*

STATEMENT OF ACCOUNTS FOR THE YEAR ENDED 31 DECEMBER 1993

1992	INCOME & EXPENDITURE	*1993*
	INCOME	
3877	Subscriptions	4139
166	Donations	202
358	Tax reclaimed	-
470	Bank Interest	195
247	Supper	201
-	General field meetings, surplus	149
1999	Proceedings: grants 500, sales 482.99	983
145	Sale of surplus journals & books	168
49	Entomological Section funds returned	-
7311	Total Income	6038
	EXPENDITURE	
79	Bank charges	85
21	Donations	21
1977	Proceedings and Bird Report	1966
175	Library, books	208
35	binding	-
298	subscriptions & journals	279
125	fire insurance	138
-	fittings	42
-	expenses re sales	25
790	General post & telephone	690
1050	Gen. printing & stationery	1070
449	Meetings expenses	481
32	General field meetings, loss	-
180	Section Grants	130
5211	Total Expend.	5134
2100	Surplus on year	904
7311		6038

1992	BALANCE SHEET AT 31 DECEMBER	*1993*
	ASSETS	
5000	Nat. Savings Income Bonds	6000
1950	Nat. Savings Bank	581
564	Cash at bank - current a/c	827
9077	Cash at bank - high int. a/c	9393
	Cash in hand (Treasurer)	2
4	Prepayments(journals 93.5, other 14.0	108
-1907	Less creditors (subscriptions in advance 271, room hire 160, Proceedings for 1992 1429, other 43)	-1903
14688	Total	15008
	REPRESENTED BY	
6693	General fund at 31/12/1993	6693
	Add surplus on year	904
	Benefactors' Funds:	
290	Harry Savory Illustrations Fund	193
282	Conservation Appeal	185
6950	Hector Hockey Memorial Fund	6580
473	R. G. Williams Memorial Fund	459
14688		15008

BENEFACTORS' FUNDS

1992	*Receipts and Payments during year*	*1993*
	Harry Savory Illustrations Fund	
288	Fund at 31 December 1992	290
2	Donations received	2.5
-	Less grant made	-100
290		192.5
	Conservation Appeal	
167	Fund at 31 December 1992	282
115	Donations received	2.5
-	Less grant made	-100
282		184.5
	Hector Hockey Memorial Fund	
6677	Fund at 31 December 1992	6950
573	Add year's investment income	424
-300	Less four grants made	-794
6950		6580
	R. G. Williams Memorial Fund	
630	Fund at 31 December 1992	473
360	Additions	12
-517	Less purchase made	-26
473		459

NOTES TO THE ACCOUNTS

(1) No value is placed upon the stock of the Society's publications

(2) These accounts do not record any balances held by sectional treasurers nor the Ornithological Section's Special Fund of £733·31

(3) The Hector Hockey Fund is represented by the Income Bonds and the National Savings Bank Account.

S. M. TAYLOR
Hon. Treasurer, 1993
March 23, 1995

S.M. Taylor

T. B. SILCOCKS
Hon. Auditor
March 23, 1995

GENERAL & SECTIONAL PROCEEDINGS

PAST PRESIDENTS

WILLIAM SANDERS	1862
HENRY E. FRIPP	1876
GEORGE FORSTER BURDER	1880
JOHN BEDDOE	1883
Professor WILLIAM RAMSAY	1884
Rev. THOMAS HINCKS	1887
Professor C. LLOYD MORGAN	1890
Professor ADOLPH LEIPNER	1893
Professor SYDNEY YOUNG	1894
S. H. SWAYNE	1897
Professor C. LLOYD MORGAN	1899
ARTHUR B. PROWSE	1901
C. K. RUDGE	1904
JAMES W. WHITE	1907
G. MUNRO SMITH	1910
Miss I. M. ROPER	1913
G. C. GRIFFITHS	1917
ERNEST (later Sir Ernest) COOK	1919
H. WOMERSLEY	1922
Professor O. V. DARBISHIRE	1924
JAMES RAFTER	1927
A. L. FLEMMING	1930
J. W. TUTCHER	1930
F. S. WALLIS	1933
Professor O. V. DARBISHIRE	1934
G. E. J. McMURTRIE	1935
Professor MACGREGOR SKENE	1938
H. TETLEY	1942
Sir LEWIS L. FERNOR	1945
F. W. EVENS	1948
H. H. DAVIS	1950
Professor W. F. WHITTARD	1952
J. H. SAVORY	1954
R. BASSINDALE	1956
Miss M. H. ROGERS	1958
F. COLES PHILLIPS	1960
H. H. DAVIS	1962
R. J. G. SAVAGE	1963
A. F. DEVONSHIRE	1965
F. R. STERNE	1966
R. BRADSHAW	1968
S. M. TAYLOR	1970
Mrs A. F. HOLLOWELL	1972
D. H. PEREGRINE	1974
D. HAMILTON	1976
J. F. W. McOMIE	1978
J. W. COWIE	1980
J. G. PRINCE	1982
V. D. DENNISON	1983
R. M. PAYNE	1985
T. E. THOMPSON	1987
Miss R. C. LEE	1989
R. G. SYMES	1991

Proceedings of the Bristol Naturalists' Society (1993), **53**: 13-21.

AVON & DISTRICT INVERTEBRATE REPORT, 1993

compiled by R. J. BARNETT

Bristol City Museum & Art Gallery, Queen's Road, Bristol BS8 1RL

INTRODUCTION

Overall 1993 was regarded by many as a poor year for invertebrates, being cool and wet. However, this impression may have been gained by the weather deterring recorders from venturing out, rather than the invertebrates themselves. Despite this the number of recorders in the region increased this year, thanks largely to the Avon Butterfly Project (ABP) and the Bristol & District Moth Group, the former servicing a mailing list of over one hundred and the latter approaching half that number. Both groups organised and coordinated field meetings and winter talks.

Sadly the 1993 butterfly records submitted to the ABP seem to confirm that the High Brown and Pearl-bordered Fritillary no longer occur in the area. It revealed concern too over the status of the Marsh Fritillary and Adonis Blue, and probably also for the Small and Chalkhill Blues and the Duke of Burgundy Fritillary. The Holly Blue population, which had dramatically crashed during 1992, remained very low with only sixteen records from twelve sites. This compares with an average of about 130 records for each of the seasons 1990 to 1992. It is thought that the decline, reflected nationally, is largely due to an increase in its specific parasitoid, *Listrodomus nycthemerus*. 1993 was also a poor year for migrants, with no records of the Clouded Yellow. Positive news was of an Essex Skipper sighting which may indicate it is resident but seldom noted in the region.

The Moth Group held nine field meetings and was also represented at one Somerset Moth group meeting. The most succesful meeting was held in June at Cleaves Wood near Wellow. Five mercury vapour lights attended by thirteen moth enthusiasts recorded more than 120 species. Three species were of national rarity and four were first records in the region in recent years. Other interesting species recorded over the year included the Cypress Pug, which has been expanding its range nationally. In the less well recorded orders, Keith Alexander of the National Trust Biological Survey has submitted some exceptional records of beetles and flies. E. and D. Levy visited Combe Dingle on two occasions and reported 37 species of hoverfly. The Chew Valley Ringing Group collected parasitic hippoboscid flies for the City Museum & Art Gallery and the recently arrived social wasp *Dolichovespula media* was found on three occasions.

A new recording group was established in 1993, under the chairmanship of English Nature warden Tony Robinson, specifically to record invertebrates on the Gordano Valley National Nature Reserve. This interesting site produced some rare beetles, *Pryyhalta viburni* and *Aphthona lutescens* recorded by Chris Wiltshire, and will no doubt reveal more in future seasons.

I am, as always, extremely grateful to all who have submitted sightings, directly to me or to the Bristol Regional Environmental Records Centre (BRERC), and to other recording schemes which I have been able to draw upon in compiling this report. My apologies if your particular records are not cited in what has to be a truncated and subjective choice of interesting species.

I am pleased to report that John Weeks has submitted a weather synopsis for 1993 which is included here. In a very encouraging development, Robert Cropper has written the Orthoptera summary in this report and Tony Smith the Mollusc report. The latter reflects the formation of a project to map by tetrad the slugs and snails of the old county of Somerset (including south Avon). I hope that this could perhaps herald a return to the detailed summaries carried in previous *Proceedings* compiled by respective experts in particular groups.

Recorders mentioned in the species lists: D. J. L. Agassiz (DJLA), K. Alexander (KA), M. Bailey (MB), R. J. Barnett (RJB), Mrs J. Boyd (JB), Bristol & District Moth Group (BDMG), I. & J. Burfield (I&JB), Ms P. Burrell (PB), P. J. Chadwick (PJC), Chew Valley Ringing Group (CVRG), Mrs E. Clapson (EC), M. Cotterill (MC), E. Courtney (EC), R. S. Cropper (RSC), A. Daw (AD), E. A. Dean (EAD), J. Evans (JE), R. Higgins (RH), J. Martin (JM), P. Martin (PM), J. D. Mastrangelo (JDM), A. Moulin (AM), Mrs F. Moulin (FM), C. & P. Mulcock (C&PM), A. J. Musgrove (AJM), S. Preddy (SP), A. Pym (AP), J. Roberts (JR), K. Vickery (KV), R. E. Warriner (REW), D. Watts (DW), C. Wiltshire (CW), A. Woodhall (AW).

Scientific nomenclature follows the checklists of Agassiz (1987), Bradley *et al.* (1972), Bradley & Fletcher (1979), Fitton (1978), Marshall & Haes (1988), Pope (1977), Potts (1964) and Smith (1976).

WEATHER SYNOPSIS (by John Weeks)

1993's mean temperature of 10·4° C was the same as 1991's, but was 0·3° C lower than 1992's. This slight improvement noted in 1992 continued until the end of June 1993, after which there was a turn for the worse. There were claims in the media that 1993 had been one of the wettest years on record, but this was not the case for Yatton. The total rainfall of 861·4mm, although it was 102% of the average over the previous ten years, was exceeded five times in those years (the wettest being 1985 with 951·5mm).

There was no lying snow during the winter; in fact the only snow to fall was for a few minutes at the end of a thunderstorm on 12 January. There were only four dry days in January, but this excess of rain was offset by an extremely dry February (the driest since 1986) and a dry March. A minimum temperature of –7·3 °C on 26 March was the lowest in that month since 1988. April was the wettest since 1987 with no very cold nights, but May provided a slight set-back. June was, overall, not far from normal with the hottest weather at the end and no rain after the 18th. It was also thunder-free here in Yatton, although parts of the south-west suffered severe storms. July commenced a succession of five months with lower than average temperatures, and in both August and September the means were the lowest since 1986. A slight ground frost on 26 September was the earliest in the season since 1986, and it was the wettest September since 1984.

TABLE 1. Monthly and seasonal trends in climate during 1993.

	Monthly differences			*Seasonal differences*	
	Max. T°C	*% Rain*	*% Sun*	*Max. T°C*	*% Rain*
Dec.'92	–2·0	85	70		
Jan.'93	+2·5	140	65		
Feb.	+0·7	16	70		
Mar.	+0·8	35	95	+0·8	90
Apr.	+0.5	115	70		
May	–0·6	90	90		
Jun.	+1·1	90	110	+0·3	75
Jul.	–2·1	135	80		
Aug.	–1·0	40	110		
Sep.	–1·1	150	100	–0·7	85
Oct.	–2·1	100	135		
Nov.	–2·2	75	90	–1·8	110

October began mild and very wet but in mid-month came a succession of six nights of damaging frosts; there was very little rain after 12th. November repeated this pattern; the first two weeks were very mild followed by a longer run of frosts, with the coldest night of the year occurring on 22nd/23rd (minimum of –9·4° C).

Overall, 1993 was cool, wet and short on sun. Remarkably the maximum temperature did not reach the "80's" at all, the nearest approach being 79·8° F on 28 June. Some similarities with 1986 are noted above.

The difference between the rainfall figures given for Long Ashton in *Bristol Botany in 1993* and for Yatton given above may surprise some readers. The two stations are only 10 kilometres apart, but it is a fact that weather conditions can vary considerably over quite short distances, for a number of reasons. The commonest of these is when rainfall is convectional in nature, i.e. during local thunderstorms. Secondly, topographical features cause appreciable differences; for example, the total rainfall recorded in 1993 at the climatological station in Minehead was 837·1 mm, while just 5 km further west at Tivington 1039·2 mm were recorded. Minehead has an easterly aspect, being sheltered from the west by North Hill; Tivington lies at the head of a west-sloping valley.

SPECIES OF NOTE IN 1993

ORTHOPTERA (grasshoppers and crickets) (all records RSC)

Oak Bush-cricket *Meconema thalassinum* (DeG.) The following are new 10km square records. Berrow ST2952, 6 August; Ebbor Gorge NNR ST5284, 23 July; Rode ST8052, 3 October.

Great Green Bush-cricket *Tettigonia viridissima* L. Easton, Wells ST5148, ST 5248 23 July (first recorded from here by J.F.Burton in 1964 and the easternmost site known on Mendip); Walton Moor, Gordano Valley ST4372, 25 July; Canada Farm, Shapwick Heath ST4140, 5 September (rare in this 10km square).

Slender Groundhopper *Tetrix subulata* (L.) Highbridge ST3247, 3 May, several on bare mud around pond; Tealham Moor ST4145, 18 September, a few on bare peat at margin of rhyne.

Common Groundhopper *Tetrix undulata* (Sowb.) Leighton Hanging ST7044, 30 August; Hollow Marsh STNC Reserve ST6156, 11 September.

Large Marsh Grasshopper *Stethophyma grossum* (L.) Peat Moors, 4 September, four stridulating males.

Woodland Grasshopper *Omocestus rufipes* (Zett.) Downhead ST6846, 8 August; Asham Wood ST7044, 30 August. These are the second and third localities for East Mendip following its initial discovery in 1991.

Lesser Marsh Grasshopper *Chorthippus albomarginatus* (DeG.) Brent Knoll, ST3351, 11 September.

Mottled Grasshopper *Myrmeleotettix maculatus* (Thunb.) Broadfield Farm, Wrington ST4964, 4 September (first recorded by J.F.Burton in 1964).

DERMAPTERA (earwigs) (all records RSC)

Lesne's Earwig *Forficula lesnei* Finot Crook Peak ST3955, 14 August, 51 specimens in scrub; Loxton Hill ST3655, 22 August, 21 specimens. First found new to v.c. 5 in 1992 and v.c. 6 in 1993, now known from seven 10km squares in Somerset.

ODONATA (dragonflies)

White-legged Damselfly *Platycnemis pennipes* (Pallas) Wick ST7073, 17 June (RJB); Swineford ST6868, 15 August (RSC).

Emerald Damselfly *Lestes sponsa* (Hanse.) Lord's Wood ST635632, 16 July (SP).

Beautiful Demoiselle *Calopteryx virgo* (L.) Wick ST7073, 17 June (RJB).

Brown Hawker *Aeshna grandis* (L.) Lord's Wood ST636632, 16 July (SP).

Ruddy Darter *Sympetrum sanguineum* (Mull.) Lord's Wood ST635632, 16 July (SP); Gordano Valley NNR ST4373, 22 August (RJB).

HEMIPTERA (true bugs)

Corizus hyoscyami (L.) Berrow Dunes ST2952, 14 August (RJB); Burnham-on-Sea ST3050, 27 September, one in garden on Fuschia (RSC).

Chorosoma schillingi (Schum.) Berrow Dunes ST2952, 14 August (RJB).

Pilophorus perplexus Doug. & Scott Ashton Court ST557720, 23 August (RJB).

Dichrooscytus rufipennis (Fall.) Cleaves Wood ST760573, 25 June (RJB).

Ranatra linearis (L.) Pawlett ST2742, 3 July; West Huntspill ST2945, 18 August (nymph); Tealham Moor ST4145, 3 October; Mudgley ST4445, 6 November. All records single specimens (RSC).

Ledra aurita (L.) Walton Hill, Street ST4635, 30 August, one on maple (RSC).

TRICHOPTERA (caddis flies)

Stenophylax permistus McL. Cook's Hill Holes, Ebbor Gorge ST5248, 31 October (RSC).

LEPIDOPTERA (butterflies)

Essex Skipper *Thymelicus lineola* (Ochs.) Five Arches Nature Reserve ST6754, 3 August (SP).

Wood White *Leptidea sinapis* (L.) Horton ST7485, 10 June (JDM).

Small Blue *Cupido minimus* (Fuess.) Dolebury Warren ST4458 (AD, PM); Draycott Sleights ST4851 (I&JB, AJM, CPM, REW); Stinchcombe Hill ST7498, 10 June (EC).

Adonis Blue *Lysandra bellargus* (Rott.) Draycott Sleights ST45, spring brood (JB).

Marsh Fritillary *Eurodryas aurinia* (Rott.) Folly Farm ST6060, ST6160, 28 May to 4 June (AM); Shapwick Heath ST4240, 8 June (REW).

LEPIDOPTERA (macro-moths)

Currant Clearwing *Synanthedon tipuliformis* (Cl.) Stapleton ST57 (EC).

Small Eggar *Eriogaster lanestris* (L.) Burnham-on-Sea ST3149, ST3150, 23 June, larval webs, one on *Prunus spinosa*, one on *Crataegus monogyna*; West Huntspill ST2946, 28 June, larval web on *Prunus spinosa*; Pawlett ST2742, 3 July, larval web on *Crataegus monogyna*. All records RSC.

Silky Wave *Idaea dilutaria* (Hb.) Avon Gorge ST5674, 30 June (RJB *et al.*).

Chalk Carpet *Scotopteryx bipunctaria* ([D. & S.]) Dolebury Warren ST45 (RH, JM); Town Quarry, Weston-super-Mare ST3262 (EAD).

Ruddy Carpet *Catarhoe rubidata* ([D. & S.]) Timsbury ST659587 (MB).

Juniper Carpet *Thera juniperata* (L.) Dolberrow ST446591 (MC).

Mottled Grey *Colostygia multistrigaria* (Haw.) Dolberrow ST446591 (MC).

Brown Scallop *Philereme vetulata* ([D. & S.]) Cleaves Wood ST760573, 25 June (BDMG); Leigh Woods ST5573, 2 July (RJB et al); Lower Woods, Wetmoor ST742873, 16 July (BDMG); Town Quarry, Weston-super-Mare ST3262 (EAD).

Maple Pug *Eupithecia inturbata* (Hb.) Weston Big Wood ST4575, 6 August (BDMG).

Netted Pug *Eupithecia venosata* (Fabr.) Conygre Grove, Filton ST6179 (AP).

Cypress Pug *Eupithecia phoeniceata* (Ramb.) Berrow Dunes ST292524, 14 August (RJB *et al.*); Dolberrow ST446591 (MC).

Chimney Sweeper *Odezia atrata* (L.) Middleton Farm ST7574, 7 June (PJC); Dodington Ash ST7577, 20 June (PJC); Dyrham Park ST7475, 20 June (JM); Battlefields ST7270, 21 June (PJC).

Dingy Shell *Euchoeca nebulata* (Scop.) Town Quarry, Weston-super-Mare ST3262, 20 July (EAD).

Small Seraphim *Pterapherapteryx sexalata* (Retz.) Gordano Valley NNR ST4372, 21 May (BDMG).

Yellow Shell *Aspitates ochrearia* (Rossi) Berrow Dunes ST2952, 14 August (RJB *et al.*); Sand Point ST3265, 5 June (JM).

Death's-head Hawk-moth *Acherontia atropos* (L.) Cheddar Gorge ST45, June (*per* AW).

Four-spotted Footman *Lithosia quadra* (L.) Dolberrow ST446591 (MC); Sand Bay ST3365 (EAD).

Cream-spot Tiger *Arctia villica* (L.) Brean Down ST296586 (JR).

Scarlet Tiger *Callimorpha dominula* (L.) East Lambrook ST4318, 25 June (PB); Watledge SO8400, 27 June (RJB).

Dotted Rustic *Rhyacia simulans* (Hufn.) Bath ST6964, 15 September (DW).

Pearly Underwing *Peridroma saucia* (Hb.) Bristol ST588735, 13 February (PJC).

Blossom Underwing *Orthosia miniosa* ([D. & S.]) Dolberrow ST446591 (MC).

Dotted Chestnut *Conistra rubiginea* ([D. & S.]) Leigh Woods ST5573, 20 March (KV *et al.*).

Brown-veined Wainscot *Archanara dissoluta* (Treit.) Chew Valley Lake ST5658, 27 August (BDMG).

Pinion-streaked Snout *Schrankia costaestrigalis* (Steph.) Dolberrow ST446591 (MC).

LEPIDOPTERA (micro-moths)

Nemophora cupriacella (Hb.) Saddlewood Roughs ST8089, 10 July (RJB).

Narycia monilifera (Geoff.) Bourton Combe ST5068, 15 April, larval signs (DJLA).

Cedestis gysseleniella (Zell.) Cleaves Wood ST760573, 25 June (BDMG).

Coleophora trifolli (Curt.) Cleaves Wood ST760573, 25 June (BDMG).

Ethmia dodocea (Haw.) Cleaves Wood ST760573, 25 June (BDMG).

Telephila schmidtiellus (Heyd.) Weston Big Wood ST4575, 6 August (BDMG).

Scythris picaepennis (Haw.) Walton Common ST4273, 24 June (RJB).

Ancylis diminutana (Haw.) Gordano Valley NNR ST 4372, 21 May (BDMG).

Pammene regiana (Zell.) Bourton Combe ST5068, 15 April, larval signs (DJLA).

Crambus pratella (L.) Willsbridge Mill ST665708 (JE).

Pempeliella diluta (Haw.) Cleaves Wood ST7557, 22 June (RJB), ST760573, 25 June (BDMG); Lower Woods, Wetmoor ST742873, 16 July (BDMG).

Pterophorus tridactyla (L.) Walton Common ST4273, 24 June (RJB).

Pterophorus galactodactyla ([D. & S.]) Cleaves Wood ST7557, 25 June (BDMG).

COLEOPTERA (beetles)

Panagaeus bipustulatus (F.) Iron Mills Common, Nailsworth ST863995, 25 March, remnants beneath rock (KA).

Dytiscus circumflexus Fabr. Berrow Dunes ST2952, 14 August, at light (RJB).

Rose Chafer *Cetonia aurata* (L.) Berkeley Square ST578731, 5 April (RJB); Chescombe Road, Yatton ST4265, 19 April (FM): Brandon Hill ST5772, 15 June (RJB).

Agrilus sinuatus (Oliv.) Whitcliff Park, Berkeley ST670970, 17 October, borings under hawthorn bark (KA).

Stenagostus rhombeus (Oliv.) Lower Woods, Wetmoor ST742873, 16 July, at light (RJB).

Glow-worm *Lampyris noctiluca* (L.) Loxton Hill ST3656, 9 May, larva under stone (RSC).

Trinodes hirtus (F.) Whitcliff Park, Berkeley ST670970, 27 March, larvae under bark on living oak pollard, 2nd Gloucestershire locality (KA).

Diplocoelus fagi Guerin-Meneville Hailey Wood, Cirencester SO9500, 26 March, under bark on fallen beech limb (KA).

Cteniopus sulphureus (L.) Durdham Down ST562744, 30 June (RJB).

Metoecus paradoxus (L.) Kingswood ST67 (Kingswood District Council Environmental Health Dept. *per* RJB).

Ischnomera sanguinicollis (F.) Hailey Wood, Cirencester SO9500, 5 June (KA).

Oncomera femorata (Fabr.) Leigh Woods NNR ST5573, 30 May, at light (RJB).

Asemum striatum (L.) Ashton Court ST557720, 23 August (RJB).

Phymatodes testaceus (L.) Hailey Wood, Cirencester SO9500, 26 March, borings in oak (KA); Leigh Woods NNR ST5573, 30 May, one adult (RJB).

Cryptocephalus moraei (L.) Walton Common ST4273, 24 June (RJB); Durdham Down ST562744, 30 June (RJB).

Pyrrhalta viburni (Payk.) Gordano Valley NNR ST4373, 22 August (CW).

Aphthona lutescens (Gyll.) Gordano Valley NNR ST4373, 22 August (CW).

Platyrhinus resinosus (Scop.) Hailey Wod, Cirencester SO9500, 26 March, 4 April (KA).

HYMENOPTERA (bees, wasps and ants)

Velvet Ant *Mutilla europaea* L. Westhay Moor ST4544, 4 September, male (RSC).

Lasius brunneus (Latr.) Whitcliff Park, Berkeley ST670970, 17 October, nest in base of oak in deer park, 1st record for v.c. 34 (West Glos.) and most south-westerly site in the UK (KA).

Ectemnius continuus (Fabr.) Gordano Valley NNR ST4373, 22 August (CW).

DIPTERA (flies)

Odontomyia ornata (Meig.) Pawlett ST2742, 22 May, larvae in rhyne; Mudgley ST4445, 27 June, pupa in rhyne, adult emerged 1 July; Common Moor, Glastonbury ST4940, 11 July, adult. All records RSC.

Odontomyia tigrina (Fabr.) Pawlett ST2742, 3 July, a few adults (RSC).

Odontomyia viridula (Fabr.) Mudgley ST4545, 27 June, a few adults; Pawlett ST2742, 3 July, a few adults. Both records RSC.

Stratiomys singularior Mudgley ST4545, 27 June, three females; Westhay Moor ST4544, 7 August, one adult; Tealham Moor ST3945 and ST4045, 8 August, several adults. All records RSC.

Psilocephala melaleuca (Loew) Hailey Wood, Cirencester SO9500, 4 April, larva in oak red rot. 1st record for Gloucestershire (KA conf. A. Stubbs).

Epistrophella euchroma (Kowarz) Combe Dingle ST57, 8 May (E&DL).

Chrysotoxum festivum (L.) Walton Common ST4273, 24 June (RJB).

Cheilosia soror (Zett.) Combe Dingle ST57, 31 July (E&DL).

Volucella zonaria (Poda) Bristol Zoo ST5674, 7 August (RJB).

Sericomyia silentis (Harris) Westhay Moor ST4544, 4 September (RSC); Shapwick Heath ST4240, 5 September (RSC).

Criorhina asilica (Fall.) Hailey Wood, Cirencester SO9500, 5 June (KA).

Criorhina berberina (Fabr.) Lime Breach Wood ST4672, 15 April (RJB).

Conops quadrifasciata DeG. Combe Dingle ST57, 31 July (E&DL).

Physocephala rufipes (Fabr.) Great Breach Wood ST5031, 24 July (RSC).

Ornithomya avicularia (L.) Chew Valley Lake ST5658, hosts - Song Thrush, Swallow, Pied Wagtail, Blackbird, Starling, Reed Warbler (CVRG det. RJB).

Ornithomya fringillina Curt. Chew Valley Lake ST5658, hosts - Whitethroat, Dunnock, Robin, Reed Warbler (CVRG det. RJB).

Crataerina hirundinis (L.) Chew Valley Lake ST5658, hosts - Swallow, Sand Martin, House Martin, Swift (CVRG det. RJB).

Crataerina pallida (Lat.) Chew Valley Lake ST5658, host - Swift (CVRG det. RJB).

MOLLUSCS

The Conchological Society of the British Isles held a meeting in June in Avon, at Gordano, Yatton and Kingston Seymour. Various other surveys and field trips took place across Avon and Somerset. The Mollusc Atlas was launched by the Somerset Invertebrates Group. The most regular work is carried out by the West Mendip Invertebrates Group, meeting every Saturday and not restricting themselves to the Mendips.

Greater numbers of the increasingly rare Pea Mussel *Pisidium pseudisphaerium* were found on the Avon and Somerset Levels. The only other known sites are both in Sussex.

Two inland sites for the coastal sand dune species, the Pointed Snail *Cochlicella acuta* were found at Kingston Seymour and Goblin Combe car park. The distribution of the River Mussels, *Unio tumidus* (Painter's River Mussel) and *Unio pictorum* (Swollen River Mussel), was found to overlap slightly - the former in larger rivers and the Taunton Canal and the latter in the main drains on the Levels and some in the main rivers.

New recorders for this interesting and rewarding study of our molluscs are always welcome.

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1) The editor welcomes original papers on the natural history of Avon and surrounding areas for consideration for publication in the *Proceedings*. Inexperienced authors may obtain advice from members of the Publications Committee. Authors should bear in mind that their readers will not usually be specialists in the particular subject, and that unnecessarily technical language can be a barrier to understanding.

2) All items for consideration should reach the editor by the end of February in each year. If there is likely to be a problem with this target date please contact the editor in advance.

3) Manuscripts should be double-spaced, with wide margins, and on one side of the paper only. The author should retain a copy.

4) The wording should follow the style and format of the *Proceedings*. Abbreviations should not normally be used, especially in the references. An abstract should be supplied, and the text should be broken up by appropriate headings and sub-headings and accompanied by relevant illustrations. Captions to illustrations should be given separately at the end of the text.

5) Originals, not copies, of photos, slides, line drawings, diagrams and maps should be submitted - returnable on request. Drawings and other diagrams should not be more than twice final size, and made in black medium. Photos and slides may be submitted as prints, positives or negatives, preferably monochrome. Graphs, charts and simple diagrams may most readily be produced by computer graphics; advice and help with this are available.

6) References should be listed at the end of the text in alphabetical order of the principal author's name, and should take the following form.

   Book: AUTHOR (DATE). *Title*. Place of publication, Publisher. E.g. RACKHAM, O. (1986). *The history of the countryside*. London, J. M. Dent.

   Paper: AUTHOR (DATE). Title. *Journal name*, **volume**, (part), page nos. E.g. ROSS, S. M. & HEATHWAITE, A. L. (1986). West Sedgemoor: its peat stratigraphy and peat chemistry. *Proceedings of the Bristol Naturalists' Society*, **44**, 19-25.

7) It is very helpful if the text can also be submitted on a magnetic disk readable under MS-DOS (any version) or *Windows*, either as an ASCII ("text" or "print" file) or as a formatted file produced by any well-known word processing software. A formatted version is especially valuable where many scientific names are involved.

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AVON MAMMAL REPORT, 1993

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INTRODUCTION

This is the fifth recent Mammal Report for Avon. It is intended to be a wide ranging review of the study of and involvement with mammals in and around Avon during 1993. Probably the highlight of the year was the discovery of the largest known British Leisler's bat roost in the roof of a house in Clifton.

REPORTS ON MAMMALS·

INSECTIVORA (hedgehogs, moles and shrews)

Hedgehog *Erinaceus europaeus.* The Mammal Society Hedgehog Road Kill Survey continued in 1993. Some interesting regional differences are now becoming apparent with the South West of England (including Avon) again coming last in the ranking with only 1·36 hedgehogs per 100 miles in 1992 and 1·59 per 100 miles in 1993. The North East remains in top place with 8·13 and 8·88 hedgehogs per 100 miles in 1992 and 1993 respectively (P. Morris *pers. comm.*).

Warwick (1993) reported on a radio tracking study of the fate of injured and underweight hedgehogs released back into the wild after periods of recuperation at the RSPCA wildlife hospital at West Hatch, Taunton. Twelve hedgehogs fitted with radio transmitters and luminous tags were released on a farm in Devon (all had been rescued as underweight juveniles the previous autumn). They were released in two batches, with the second batch being kept in pre-release cages for five days. The cages were then opened but food and bedding were provided for a further five days, giving the hogs somewhere to retreat to should they so wish. The hedgehogs soon settled down and became subject to the rigors of life as wild hedgehogs. Two were run over on the small road leading to the farm and three were killed by badgers, including the most adventurous hog Nigel (named after a certain racing driver because of his habit of disappearing at great speed). Despite these setbacks the majority of the hedgehogs successfully adapted to life in the wild, building nests and finding sufficient food to eat. It was also encouraging that there was no difference in how the two groups fared.

CHIROPTERA (bats)

Bat records for Avon in 1993 have been compiled by Dr Gareth Jones (Department of Zoology, University of Bristol) and David Trump. Records are from Dr Gareth Jones (GJ), David Clarke (DC), Tony Sladden (TS), Robert Howard (RH), Chris Sperring (CS), Robert Cropper (RSC), Norbert Rottcher (NR), Lorna Beal (LB), Adam Britton (ARCB), A. F. Jayne (AFJ), Lyn Jenkins (LJ), Doug Woods (DW), Nigel Cameron (NC), Diana Desmond (DD), Simon Christian (SC), P. L. Duvergé (PLD) and R. D. Ransome (RDR), Avon Bat Group (ABG), David Trump (DT).

Rhinolophidae (horseshoe bats)

Greater horseshoe bat *Rhinolophus ferrumequinum*. Spring site in Gordano first occupied on 14 April, when 5 torpid bats present. Peak count here of 10 shows a decline over the past 8 years. At the traditional underground site, a maximum of 41 adults and 17 babies counted. The nearby stable block reached a maximum of 55 adults on 14 July, and 73 bats (adults and flying young) left the roost on 11 August. The combined total for these two sites was therefore 126 bats maximum, 91 of which were adults (GJ, PLD). A sparrow hawk took 10-12 bats at the SE Avon nursery site during April. The hawk was captured under licence from English Nature, and relocated some 100 km distant. The hawk showed little fear of people, and cere damage on the bill (CS) suggested that the bird had been in captivity until recently. This breeding site continues to thrive, with a maximum of 223 adults at peak breeding time (16 July), and an estimated 64 young present (TS, PLD). A female ringed at Read's Cavern in November 1963 was re-found at Dundry on 7 March, and was therefore in its 30th year (RSC). At least one bat emerged at dusk at Cleeve roost, 22 February (GJ). Two found starved at Limpley Stoke, early May. Stone mines in SE of county held 105 hibernating bats in early January (RDR, GJ). Bats active over much of winter at breeding site in SE Avon: up to 19 emerged in January, and bats active on 4/21 nights in January, 8/21 nights in February, 13/18 nights in March (TS). Counts from hibernacula in NW of county gave 16 on 16 January, 12 on 3 April and 12 on 23 October (RDR). Twenty-five in Cleeve hibernacula, 16 January (DC). Two bats recorded from stone mine near Colerne ST7870 on 7 September, one of which was ringed (AFJ).

Lesser horseshoe bat *Rhinolophus hipposideros*. A roost near Limpley Stoke held 42 bats on 9 June, 74 on 11 July (TS). Thirteen at Hutton ST 3558 on 18 August (DW). Ten hibernating in Read's Cavern, 28 November (RSC). Emergence noted at Cleeve hibernaculum on 2 and 22 February (GJ). Stone mines in SE of county held 85 hibernating bats in early January (RDR, GJ). Counts from hibernacula in NW of county gave 8 on 16 January, 8 on 3 April and 7 on 23 October (RDR). Eight in Cleeve hibernacula, 16 January (DC). One in stone mine near Colerne ST7870 on 7 September (AFJ). Two in man-made tunnel in garden at Clapton-in-Gordano ST 4773 on 28 September (AFJ). A small summer roost (6 individuals) was reported from the Wynhol viaduct on the M5 ST4472 (SC).

Vespertilionidae (vespertilionid bats)

Whiskered bat *Myotis mystacinus*. Male killed by cat at Nailsea ST4569, 17 August (ARCB). Single bat (perhaps part of a small colony) at Chewton, ST6465, 21 August (RH). Male found in middle of road at Cribbs Causeway ST5780, 30 August, but died later (AFJ). Male hibernating at East Harptree Coombe, 31 October (RSC).

Whiskered/Brandt's bat *Myotis mystacinus/brandti*. One in stone mines in SE of county 3 January (GJ, RDR). Other individual records at Cleeve, ST4665, 10 August (SC); Hartcliffe, ST5867, 2 August; Nailsea, ST4869, 17 August; Coombe Dingle, ST5577, 23 July; Hanham Mills, 16 July (all AFJ).

Daubenton's bat *Myotis daubentoni*. Roost occupied near Swineford, but impossible to count (GJ). Several foraging at Eastville Lake, ST6175, 7 July (GJ). Individual bats recorded from Knowle, ST6071, 4 August and Bitton, ST6769, 11 August (AFJ).

Natterer's bat *Myotis nattereri*. One in stone mines in SE of county, 3 January (GJ, RDR).

Serotine *Eptesicus serotinus*. Blagdon roost still occupied (53 on 1 June, LJ), and a single bat roosting at Clapton Church. One or two bats active at Limpley Stoke on 4/21 nights in January (TS). Probable serotine droppings in roof at Upton Cheyney, ST6969, 7 August (AFJ).

Leisler's bat *Nyctalus leisleri*. One found in Ashton Court Mansion on 11 February released there again soon after (GJ). Male grounded at Downend, ST6577, 24 May, released at point of capture on 21 June (AFJ). The largest known roost of this species yet documented in Britain was found in Clifton. Counts were 80 on 16 June, 320 on 27 July (includes flying young), 149 on 25 August, 59 on 23 September. One bat at the roost was very pale, almost white. Emaciated female found in Clifton, ST5773, on 30 June and taken into care (AFJ). Grounded juvenile in Clifton, ST5774, 21 July, released after feeding-up. Two grounded juveniles at Bristol Zoo, 5 August (female) and 10 August, and another at Sneyd Park, ST5575, 16 August (AFJ).

Noctule *Nyctalus noctula*. Frequently flying over Long Ashton in summer (GJ). Male dead at Rickford late January (GJ). Heard over Wetmoor Nature Reserve in July (GJ). Thirty-nine bats counted out of an oak tree roost near Willsbridge Mill, ST6670, 27 April (AFJ). A male bat was found floating on a stick in the Little Avon River, ST7094, on 27 July by a fisherman. It was rescued but found to have a broken left upper arm and died on 2 May (AFJ). Single bats recorded from: Winterbourne, ST6580, 17 April; Winterbourne Down, ST6579, 4 August; and Eastville, ST6171, 6 August (all AFJ).

Brown long-eared bat *Plecotus auritus*. One roosting in a Dormouse box, King's Wood, July (DC). Female hibernating in East Harptree Coombe, 3 January (RSC), and one at Banwell, 16 January (RDR). One at Compton Martin, ST5357, 23 June, and one at Brislington, 3 June (NC). Bats at Hutton Church, ST3558, 18 August (DW). Male near Radstock, ST6854, 24 July (TS). Records of individuals at: Portbury, ST5172, 3 February; Nailsea, ST4870, 12 May; Longwell Green, ST6570, 29 June; English Combe, ST7162, 1 August; Warmley, ST6672, 6 August; Charfield, ST7291, 20 August; Congresbury, ST4363, 30 August; Horton, ST7484, 31 August; East Dundry, ST5766, 17 October; Oldfield Park, ST7364, 30 October (all AFJ).

Pipistrelle *Pipistrellus pipistrellus*. GJ did a winter bat survey at Abbot's Pool, ST5375, visiting the site every night between 4-24 January. Bat detectors were set at 40 and 50 kHz, and a 15-20 minute transect walked at dusk. The only activity was on the coldest night (2°C), 4 January, when 1-2 were heard. Pipistrelles were active again there on 24 January and 28 January (NR, LB).

Work on the echolocation of this species suggests that pipistrelles exist as two 'phonic types', one echolocating with a frequency containing most energy at 46 kHz, the other at 55 kHz (Jones & van Parijs, 1993; Putnam, 1993; Irwin, 1993). Further work by GJ and collaborators has shown that each phonic type associated with its own type during the mating season, and that the two phonic types have subtly different mating songs. Molecular investigations, in collaboration with the Institute of Zoology (London) and the University of Aberdeen, suggest that the two phonic types differ substantially in the structure of their DNA. It therefore seems that the two types are certainly cryptic species, and differences in their appearance are now becoming apparent. Records therefore refer to the '45' and '55' kHz phonic types, for shorthand.

55 kHz 335 at Midford, ST7761, 28 July (TS). 51 emerged from a roost in Limpley Stoke, 9 July (TS). Roost at Barrow Hospital contained 214 bats on 24 May (ARCB). A roost of 98 at Yatton, ST4365, 21 July.

45 kHz Male caught at Swineford, 26 May (GJ). Roost of 66 in Stoke Bishop, ST5676, 26 July. Grounded bats from Fishponds and Kingswood, Bristol (AFJ), and Brentry (ARCB). Dead bat at Long Ashton (GJ).

Unknown Activity noted on 3 of 21 nights in January at Limpley Stoke (TS). Flying at Long Ashton, 6 March (GJ). A very early breeding year - most bats at Barrow Hospital had young on 15 June (GJ). A number of large roosts were recorded during the year: at least 1200 bats at Chew Stoke, ST5562, 7 July (RH); 783 at Ubley, ST5258, 12 July (ABG); 358 at Keynsham, ST6568, 14 July (AFJ); 200+ at Ubley, ST5258, 28 July (AFJ); 117 at Nailsea, ST4669, 20 June (DPCT); 100+ at Puckle- church, ST6976, 26 June (AFJ); 100+ at Nempnett Thrubwell, ST5359, 21 June (AFJ); 97 at Portishead, ST4677, 6 June (AFJ); 94* at Bath, ST7666, 6 July (AFJ); 70+ at Chew Magna, ST5763, 7 July (AFJ/DD); 40+ at Butcombe, ST5161, 10 June (AFJ); 34+ at Yatton, ST4167, 17 June; 30+ at Wick, ST7073, 11 August (DD); 30+* at St Annes, ST6272, 30 June (AFJ); 30+ at Tickenham, ST4371, 1 September (DD); 15 at Weston-Super-Mare, ST3364, 11 June (DW).

Other smaller roosts at: Yatton, ST4167, 17 June (AFJ); Midsomer Norton, ST6553, 11 June; Winterbourne Down, ST6579, 4 June (AFJ); Stanton Drew, ST5963, 26 June (AFJ/DD); Sneyd Park, ST5575, 12 July (AFJ); Wrington, ST4762, 28 July (SC); Congresbury, ST4464, 26 June (AFJ)*. Other interesting records included: a female found hanging in a shower in Downend, ST6577, 30 June (it was released at the site) (DD); a female caught up in some discarded fishing line at Damsons Bridge, Winterbourne Down, ST6579, 29 June (it was rescued and released unharmed) (AFJ); a male hanging up in the men's toilet at Two Mile Hill Junior School, Kingswood, ST6373, 7-15 June (released unharmed) (AFJ); 4 bats found dead in the church in Banwell, ST3959, 4 September (AFJ); and 6 found in a house in Clevedon, ST4070, over a period of 2 months around 28 August (AFJ). (* not positively identified as pipistrelles).

Other pipistrelle records from the following 1 km squares (AFJ and DD) (a number were found injured, the culprits usually being cats): ST3561, 4069, 4070, 4259, 4265, 4365, 4570, 4677, 4762, 4770, 4773, 5357, 5365, 5373, 5377, 5457, 5662, 5770, 5773, 5775, 5875, 5982, 6073, 6079, 6272, 6286, 6375, 6473, 6477, 6490, 6574, 6671, 6758, 6766, 6772, 6779, 6780, 6781, 6866, 7083, 7181, 7182, 7183, 7265, 7363, 7463, 7564, 7566.

Other bat news

The Avon Bat Group's bat boxes at Chew Valley and Blagdon Lakes were checked on two occasions during 1993. Single pipistrelles were found in boxes in an Oak tree at Chew Valley, ST5760, and in an Ash tree at Blagdon, ST5160, on 9 May (ABG).

Three female pipistrelles were found in a box in a Sycamore, and a male in a box in an Ash tree, both at Blagdon, ST5159, on 5 September (ABG). A number of the boxes contained bat droppings, indicating regular use as temporary roosts during the summer. The boxes continue to be attractive to blue and great tits.

During the year the Conservation Section of Avon County Council Planning Department organised the construction of an artificial bat hibernaculum at a site being infilled with waste rock produced during the construction of the Avon Ring Road (Renshaw, 1993).

LAGOMORPHA (rabbits and hares)

Brown hare *Lepus europaeus*. Records from the Gordano Valley NNR, ST4372, throughout the year, and also from ST7875 and ST7776 (both P. J. Chadwick).

The results of the first season's (October 1991 - January 1992) field work for the National Hare Survey were reported by Harris & Hutchings (1993). The survey involved walking around a one-kilometre square, three times between mid October and mid January and recording the position of each hare seen and the type of habitat in which it was found. Around 7,500 km were walked by an army of volunteer recorders throughout Britain. Based on the first season's data, the winter population of hares was estimated to be around 900,000 animals, much lower than was expected. Hares were most abundant in East Anglia, parts of eastern England, the downs of Wiltshire and Berkshire and parts of Scotland. Highest densities were around 50 hares per square kilometre. The number of hare sightings in the south west was particularly low, yet at the turn of the century hares were said to be common, especially in Devon and Cornwall. The authors speculate that reasons for the decline are many and could have included the introduction of the Ground Game Act of 1880 which allowed tenant farmers to shoot hares on their land (previously the privilege of shooting hares was reserved for the land owner). Other theories to explain the decline revolved around changes in countryside management, the reduction in range of crops grown and the loss of field boundaries. The cutting of silage grass coincides with peak leveret production and it is likely that many young hares are killed. Herbicides and other pesticides might also be implicated as well as an increase in the number of incidents involving poachers who course hares with lurchers. The results of the second season's (October 1992 - January 1993) field work might help clarify the reasons why hare numbers continue to decline.

Rabbit *Orytolagus cuniculus*. The MAFF Veterinary Investigations Centre at Langford in Avon was involved in investigating an outbreak of viral haemorrhagic disease (VHD) in which 13 out of a group of 20 pet rabbits died (Anon. 1993).

RODENTIA (rodents)

Common rat *Rattus norvegicus*. Richard Bevan (Pest Control Services Manager, Bristol City Council) reported a continuing decline in numbers of rat problems with 852 cases investigated (979 in 1992). This has been put down to the continuance of their very successful sewer baiting programme, resulting in a decline in rat problems on the surface.

House mouse *Mus domesticus*. Richard Bevan reported that an increase in numbers of house mouse complaints dealt with (1,650 compared with 1,319 in 1992) was likely to be a result of greater public awareness of the services provided by Bristol City Council.

Dormouse *Muscardinus avellanarius*. English Nature launched a very successful National Dormouse Week in October which included the Great Nut Hunt in which people were asked to visit their local woodlands and hunt for dormouse-chewed nuts. As of 17 January 1994, 3,500 people had taken part in the survey and over 6,500 chewed nuts had been sent in, of which 640 had been opened by dormice from 153 different locations. The survey runs until March 1994 and will be reported on in the next *Avon Mammal Report*.

David Clarke's regular survey of dormouse boxes in woodland near Cleeve continued during 1993. Richard Robertson of AWT reports that dormice may be present in Dowlings Wood, Bishop Sutton, ST6060.

Dormouse foraging behaviour at two contrasting sites, one in Somerset and one in Hereford, has been studied in detail (Bright & Morris, 1993). During late May, the Somerset dormice spent 50% of their time in hawthorn and 30% of their time in sycamore feeding on newly opened flowers. In late June/early July, they spent 60% of their time in flowering honeysuckle. In mid August, the dormice had moved on to Wayfaring tree (47% of radio tracking fixes) and Yew (15% of fixes). In mid October, 76% of fixes were from hazel (hazelnuts being the main food source) and 13% from blackthorn bushes. These data contrast markedly with those from the Hereford dormice, which ate Oak flowers, lepidoptera larvae, unripe hazel nuts, honeysuckle, aphids, bramble and perhaps acorns.

The study clearly implies that dormice require a diversity of tree and shrub species to provide a continuous succession of food throughout the summer. Coppice-with-standards woodland management provides the ideal habitat for dormice, creating a mosaic of different ages of shrub growth. Coppice rotation length and coupe size are likely to be critical in maintaining the variety of habitats needed to maintain a health population of dormice.

Grey squirrel *Sciurus carolinensis*. The grey squirrels of Bristol's parks hit the local headlines this year with calls both for their extermination and for their protection being heard. The two most dramatic headlines were, "Turn Army on the Squirrels" and "Poison Cull on Grey Squirrels". Bristol City Council's Wildlife Panel considered that sterilising some of the squirrels might be an option and also considered talking to researchers and animal behaviour experts to find out why grey squirrels don't damage trees in their native North America but do here (extracts from the *Bristol Evening Post*). Landowners claim that grey squirrels are destroying thousands of trees in the West each year. The Country Landowners' Association called for a humane pest control campaign to rescue broadleaf woodland plantations from devastation (*Bristol Evening Post* - in *Mammal News* 92 , Winter 1992/3).

SMALL MAMMALS

The Mammal Society announced the launch of two new small mammal surveys in 1993, the National Field Vole survey in association with the Hawk and Owl Trust (pilot survey to begin in March/ April 1994) and the National Owl Pellet Survey. A review of the first 5 years of the Woodland Small Mammal Survey will be published in *Mammal Review* in 1994.

CETACEA (whales and dolphins) and PINNIPEDIA (seals)

A voluntary scheme was launched by fisheries departments for fishermen to report incidental catches of marine mammals (1 January 1992, Article 12(4) of the *EC Habitats and Species Directive*). By October 1993 only 6 UK incidents had been reported involving 5 common porpoises, 3 common seals, 1 grey seal and 1 common dolphin. Two of the common seals and the dolphin survived and were released. The scheme was not considered to be a success as returns fall short of the number of strandings from all other sources recorded by the DoE's marine strandings co-ordinators. The scheme is currently being reconsidered (*Hansard* Written Answer, 26 October 1993, p.568). Anyone finding a stranded seal should contact their local RSPCA office and those finding stranded cetaceans should contact the local HM Coastguard.

Stack *et al.* (1993) reported cases of pox virus and calcivirus infections of grey seals (*Halichoerus grypus)* in Cornwall - the first reported case of mixed parapox virus and calicivirus infections in seals, and also the first report of a calcivirus in seals this side of the Atlantic Ocean. Parapox infection is probably widespread around the British Isles. It is thought that fish may be the natural disease reservoir of calicivirus.

CARNIVORA (carnivores)

Polecat *Mustela putorius*. After many decades of persecution by Victorian and Edwardian gamekeepers, polecats are slowly beginning to recolonise the countryside from their stronghold in Wales. They are now established in some numbers in Gloucestershire west of the River Severn and it can only be a matter of time before they make a welcome return to Avon. The Vincent Wildlife Trust is funding a three-year study of polecats by Dr Johnny Birks.

Weasel *Mustela nivalis.* A very under-recorded species (along with the stoat *Mustela erminea*), with only three records for 1993, ST7274 and ST7875 (x2), all from P. J. Chadwick.

Otter *Lutra lutra*. Otters are gradually recolonising Avon from the south. Details of sightings remain confidential.

Mink *Mustela vison.* As reported in 1992, the Mink (Keeping) Order 1992 made under the Destructive Imported Animals Act 1932 came into force on 1 January 1993. It will run for a period of 5 years before being reviewed. There are currently no mink farms in Avon. Mink are present in suitable habitats throughout the county but records are scarce.

Fox *Vulpes vulpes*. Numerous records from throughout the county, particularly from Bristol and Bath. Even Bristol City Football Club's Ashton Gate pitch fell victim to the nocturnal diggings of a family of foxes. A young fox had to be put down by the RSPCA after being caught in an illegal gin trap in Eastville (*Bristol Evening Post,* November 1993). An article on foxes, entitled "Know thy Neighbour", by Professor Stephen Harris of Bristol University appeared in *BBC Wildlife Magazine* in June 1993 to coincide with the showing on TV of "Twentieth Century Fox" in the Wildlife 100 Series - the programme that put Bristol's urban foxes on the map.

Research on urban foxes continues apace at the University of Bristol. A recent study in Bristol (Harris & White, 1993) has shown that two-thirds of dog foxes and a third of vixens will have left their family groups by the time they are a year old. What makes young foxes leave their families is not certain. There is no evidence of increasing aggression during the autumn forcing the young foxes to leave, but a study of chewed plastic ear tags suggested that adult foxes that had left the family group had been groomed less by other adults than those which remained. Vixens may benefit from staying in their parents' territory and helping to rear their younger siblings, whereas for dog foxes the best strategy may be to leave and start their own families.

John Haines reported on fox control on a small game shoot south of Bristol. He always uses lamps with a high powered rifle and starts at the foxes' main food source, the pheasant pen, about one hour before sunset. Most of the offending foxes are taken before darkness falls. Follow-up control is undertaken further away from the pheasant pen until there is a "fox-free zone" in the vicinity. It would appear that once the immediate area is cleared, the foxes occupying territories adjoining the cleared area stay out of that area until the winter months when pairing starts. If the cleared area is patrolled regularly at random times, adults and cubs stay away and can often be seen outside the cleared area. Using this method on an area of 450 acres, in the first year 25 foxes were shot. The number of sightings close to the pheasant pens fell by half. The following year, after a break of three months, fox sightings in the area remained low and the number of foxes shot fell to 12. One of the boundaries of the cleared area is a busy road. In previous years when little control was carried out, many foxes were killed on this stretch of road. However, during the first year of systematic control and patrols, only one dead fox was found. During the 3 month lull several foxes were found dead on the road.

Badger *Meles meles*. Badgers continue to be in the news following the recent changes in legislation concerning their protection (Protection of Badgers Act, 1992).

The joint master of the Beaufort Hunt was found guilty of aiding and abetting the illegal blocking of a badger sett near Chipping Sodbury. Hunt servants had blocked up the entrances to a sett the day before a hunt meet using "heavy earth" rather than the 'light' material allowed under the Protection of Badgers Act 1992. He was given a two year conditional discharge and ordered to pay £4,000 towards the £9,977 prosecution costs. The hunt were appealing against the verdict. (*Bristol Evening Post, Western Daily Press, The Guardian,* September 1993).

Five Bristol men were accused of damaging an active badger sett in Lawrence Weston. Police received a tip off and caught the men at the scene with a lurcher, several terriers, a spade and nets. Under the Protection of Badgers Act 1992, licences to enter dogs into badger setts for the purposes of fox control can be granted but in a written answer to a question, the Minister of Agriculture revealed that during the periods December 1991 - June 1992 and December 1992 - June 1993 no such licences were issued (*Hansard,* 25 January 1993, WA p.566).

Griffiths & Thomas (1993) considered that the UK badger population was stable at around 42,000 social groups. It has been suggested that the national population could increase by up to 40% (to 58,000 social groups) if illegal persecution were eliminated and patterns of rural land use were changed to include five or more of the habitat features favoured by badgers (Reason *et al.*, 1993).

An interesting paper by Griffiths (1993) summarised the uses to which badgers had been put throughout Europe, currently and historically. The range of badger-derived products is extensive. Their hard-wearing pelts made excellent carpets and rugs;

badger leather is still occasionally used to make hunting bags and knapsacks in Finland; bristle is widely used in brush making. Badgers are still hunted for meat in southern central Europe and badger fat and lard were important ingredients of folk pharmacopoeias. Badger grease can be used in the manufacture of soap and for waterproofing clothing.

Avon County Council's Planning Department provided grants to the Avon Badger Group: for the purchase of holding cages and graspers which enabled the Group to safely catch and transport sick or injured badgers; to help with the running costs of the 1991-1993 persecution survey; and to help build a badger watching hide on a Wildlife Trust Reserve (Regini, 1993).

One of the contributory factors in causing Avon County Council to over-shoot their annual budget was the £32,000 it was reported to have cost to relocate a badger sett under Christchurch Junior School in Downend (*Bristol Evening Post,* 10 June 1993).

Badgers and bovine tuberculosis. Despite the onset of badger control operations in 1975, comparatively high numbers of cattle continue to fail the tuberculin test. Many cases of TB occur repeatedly in the same locations, but the relationship between the incidence of TB and badger density remains unclear (White *et al.*, 1993). Studies at the University of Bristol by White *el al.* (1993) investigated where badgers urinated, as environmental contamination of infected badger urine was thought to be the main mode for the transmission of bovine TB. Field studies in an area with TB in both badgers and cattle showed that badgers urinated on pasture after crossing through a linear feature (such as fencing, hedgerows, woodland edges), and that the number of these crossing point urinations increases with the number of linear features crossed. The hypothesis was presented that these crossing point urinations are a major source of bovine TB infection in cattle, and that areas with increased numbers of linear features had greater levels of contamination of pasture with badger urine and hence increased opportunities for disease transmission. It was suggested that further research be directed at ways of reducing the risk of cattle coming into contact with badger faeces and urine.

Following an increase in TB cattle herd breakdowns, particularly in the South West, the Government introduced a six-point plan to tackle the problem (MAFF Press Release 214/93, 8 December 1993):

1. Research to develop effective vaccines for TB in badgers.
2. Research to develop new or improved diagnostic tests for the presence of infection in cattle and in badgers.
3. Continued monitoring of infection in the wild badger population where appropriate.
4. Continued support for research into ways of avoiding transmission of disease from badgers to cattle.
5. Co-operation with University Departments on proposed studies of the effects of badger removal operations on the badger population and its impact on the subsequent spread of disease within the badger population.

6. A trial of a new badger control strategy based on the application of the test for tuberculosis in the live badger (the trial to be undertaken in areas of the South West of England for a period of at least 5 years).

Of the 123 badgers that were shot in TB control operations in Avon in 1993, 24 (19·5%) were positive for *M. bovis* (*Hansard,* 19 January 1994, WA pp. 679-680). Badgers were implicated in over three-quarters of cattle herd TB breakdowns in the South West of England (*Hansard,* 19 January 1994, WA p. 208).

ARTIODACTYLA

Wild boar *Sus scrofa.* Wild boar are back in the Forest of Dean some 700 years after becoming extinct in Britain. An enterprising farmer has 10 sows and a boar registered under the Dangerous Wild Animals Act (1976). There are about 300 breeding sows in the UK, descended from stock captured on the Continent, where they still roam free (*The Times,* 12 May 1993).

American bison *Bison bison.* Eagle-eyed visitors to north Dorset may spot a herd of North American Bison. Apparently they produce very high quality meats for expensive London restaurants!

Muntjac *Muntiacus reevesi.* Four deer were introduced to Steep Holm in 1977 by the Warden Rodney Legg. The population of Muntjac on the island is now thought to be around 25 animals. One was washed up at Sand Point near Weston-super-Mare, having probably fallen off the steep cliffs on the island.

Roe deer *Capreolus capreolus.* Records from ST7775 and ST7472 (P. J. Chadwick), Gordano Valley NNR, Wraxall Estate and Redhill (no doubt under-recorded). The Masters of Deer Hounds Association have been criticised by the Devon and Somerset Residents' Association for Deer Protection for recognising two packs of beagles and basset-hounds that are hunting roe deer on the western fringe of Exmoor - a sport that has not been pursued in Britain for fifty years (*The Times,* 15 February 1993).

John Haines reports on studies of roe deer carried out on an estate at Wraxall (6,600 acres) and 3 farms in the Redhill area (total 650 acres). "No management of the deer has been carried out at either location for many years. Roe deer have been present at these locations for many years, but recent years, the last two in particular, have seen a steady increase in numbers. The sex ratio appears to have got out of balance with does outnumbering bucks by 2 to 1. I would estimate that the number of does has doubled in the past 3 years and I have counted as many as 10 adults feeding at once on a 9 acre plot of fodder beet. Although at the moment all the animals look very healthy and antler growth has been very good, this overcrowding will inevitably lead to disease if no form of management is carried out soon. Most authorities on deer tell us that the animal will tolerate only little in the way of disturbance in their territories. I have observed that although all the deer lying up in a wood are driven out almost every week during game shoots, they return the following day. One could speculate that they have learned to tolerate the disturbance in order to retain a good food supply in these overcrowded areas."

Red deer *Cervus elaphus.* The hunting of red deer on Exmoor and the Quantock Hills was much in the news in 1993 with the publication of the National Trust report on a two year study of hunting over Trust land (Savage, 1993). The chairman of the working party was Professor Bob Savage, a former President of the Bristol Naturalists. A detailed survey of the area commissioned from Southampton University showed that the deer populationwas around 7,000, much higher than previous "guesstimates". The sex ratio among adults was also strongly skewed in favour of females (three hinds to one stag). It was calculated that an annual cull of around 1,400 animals (20%) was needed to stabilise the population; the current cull was around 1,000 (130 taken by the hunts, around 50 as road casualties, stalkers and landowners around 600 and poachers around 200). Over half the area was farmland where deer were not welcome. High numbers of deer in the wooded combes prevented regeneration by eating all the young saplings. On the open heather moors, the deer competed with sheep and cattle. The report highlighted the need for an overall strategy to conserve the habitat and the deer, involving the local community of farmers and tenants along with the conservation bodies and the hunts. It strongly recommended setting up Deer Management Groups whose task would be to monitor the population annually, to determine the annual cull to achieve a more even sex ratio in the population and to ensure its implementation. It also stressed the need for further research into deer movements in the area and to assess their effects on agriculture, forestry and the sensitive ecology of the area.

Somerset County Council banned the Quantock Staghounds from hunting on 140 acres of council land at Over Stowey Customs Common (*The Times,* 5 August 1993). The Staghounds are fighting the ban in the courts (*Western Daily Press,* 14 September 1993).

Tuberculosis in deer Since 1984 there have been only 21 confirmed cases of TB in farmed and park deer, and 15 in wild deer in Great Britain (*MAFF News Release* 132/93, 17 September 1993).

MAFF CAMPAIGN AGAINST THE ILLEGAL POISONING OF WILDLIFE

During 1993, thirteen cases were investigated in Avon where agricultural chemicals may have been implicated in the deaths of wildlife and companion animals. Nine of these involved mammals - five involving badgers, two involving foxes, and one each for dogs and cats. The causes of death were identified in four cases: paraquat (source unknown) in a badger, metaldehyde (slug pellets) in the cases of the dogs and cat and "natural causes" being responsible for the death of one of the foxes.

PUBLICATIONS

Two important mammal books appeared in 1993. *The Atlas of Mammals in Britain* by H. R. Arnold (NERC, ITE and JNCC), published by HMSO, maps the results of over 115,000 records collected by amateur naturalists and professional zoologists between 1969 and 1991. *A Red Data Book for British Mammals* by P. A. Morris, published by the Mammal Society, reviews Britain's threatened and protected terrestrial mammals.

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BRISTOL BOTANY IN 1993

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The weather in 1993 was the wettest for a very considerable number of years, eight months having rainfall higher than the 50-year average. January and December were exceptionally wet, March, July, September and October also being much wetter than usual. On the other hand, February was particularly dry. The total rainfall for the year at Long Ashton Research Station, to which all weather values relate, was 1082 mm, about 123% of the long-term average. Overall, temperatures were fairly close to nor1mal; however, the first half of the year was somewhat warmer than usual, but the second half cooler, making the summer poorer than in the four preceding years. January was mild, but in November an exceptionally cold spell gave the lowest November minimum temperature since 1915, - 6·25°C (20·3°F) on the 24th.

The good start to the year was shown by early flowering of vernal species. In January *Daphne laureola* was in flower in Cheddar Wood, *Helleborus foetidus* at Churchill Batch, *Galanthus nivalis* in Edford Wood and *Erophila verna* on Brean Down. In February, *Narcissus pseudonarcissus* and *Lathraea squamaria* were flowering at Churchill and *Chrysosplenium oppositifolium* and *C. alternifolium* at Edford Wood. *Orchis morio* was at its best in mid-April in several sites (all records RSC). The year was remarkable for the profuse vegetative growth of almost all plants, no doubt in part attributable to the wetness. *Sorbus* and *Crataegus* flowered and fruited abundantly (PJMN).

A substantial number of important plant records were made in 1993. A first report for v.c. 34 (West Gloucestershire) is of *Zostera angustifolia* and in v.c. 6 (North Somerset) there are first records of *Juncus foliosus* (in 1992), *Rumex* × *steinii*, *Typha* × *glauca* and *Sambucus racemosa*. A considerable number of hybrids have been reported, including several of *Rumex* and *Viola*. Extensions of ranges include those of *Campanula latifolia, Chrysosplenium alternifolium* and of *Epilobium lanceolatum*. The long persistence of some species at sites from which they have not been recorded for very many years is evident from numerous reports, e.g. *Limonium vulgare* at Portishead, thought lost by 1912; *Juncus compressus* at Inglestone Common, formerly reported in 1940; *Cardamine impatiens* in Cheddar Gorge, last noted in 1950; *Salicornia dolichostachya* at Portishead, previously recorded in 1956.

A field meeting of the Botanical Society of the British Isles to study *Rubus* species was held in July in the Mendips, reported by R.D. Randall in *B.S.B.I. News,* 1994, No. **65**, pp. 55-56. The chief sites visited were Worlebury Hill, where the *Rubus* species present were mainly the more glandular ones, Burrington Common, with species representative of open ground, and Stock Hill Plantation, Priddy, where there was evidence of recent colonization and hybridization. Many of the *Rubi* seen are named in the report.

The first two meetings of the Wessex Group of the British Bryological Society were both held near Wotton-under-Edge in West Gloucestershire in 1993, led by Mr P. Martin. One, on 28 February, was in Westridge Wood and associated quarries. Among the mosses found here were *Eurhynchium schleicheri* (pathside), *E. swartzii* var. *rigidum*, *Tortula subulata* var. *subulata* and in the quarries *Campylium calcareum*, *Entodon concinnus* (quarry floor) and *Tortula marginata* (quarry face). The second meeting, held on 4 April, was in Tyley Bottom. Here bryophytes seen included the rare moss *Platygyrium repens*, plentiful and in splendid condition, *Oxystegus tenuirostris* (on concrete in stream) and the liverworts *Metzgeria temperata* and *M. fruticulosa*.

A paper by J.O. Mountford, K.H. Lakhani and F.W. Kirkham on an 'Experimental assessment of the effects of nitrogen addition under hay-cutting and aftermath grazing on the vegetation of meadows on a Somerset peat moor' was published in the *Journal of Applied Ecology*, 1993, Vol. **30**, pp. 321-332. This research, undertaken from 1986 to 1990, showed that applications of nitrogen at rates up to 200 kg ha^{-1} year^{-1} on Tadham Moor (SSSI) encouraged grasses (mainly *Lolium perenne* and *Holcus lanatus*) and a few forbs, including *Rumex acetosa*, but reduced species diversity, including species of *Carex, Juncus* and mosses. The largest cover of legumes was in plots receiving 25 kg N ha^{-1} year^{-1} but they were suppressed by high levels of nitrogen.

Also published this year (August 1993) was the *University of Bristol Avon Gorge Project Report No. 17* entitled 'The Nationally Scarce Plants of the Avon Gorge, Clifton and Durdham Downs, and Leigh Woods' by C.M. Lovatt, Libby Houston and L.C. Frost. This report (77 pp.) covers 55 species, classed as nationally scarce, with maps and very detailed documentation of former records and literature, and much information on the size of current populations from extensive surveys. Factors affecting the losses of some of these plants, notably changes in land use, structural developments and human activities, are discussed as well as conservation issues.

The death of Professor E.W. Yemm, Head of the Department of Botany at the University of Bristol from 1955 to 1974, occurred on 22 November 1993. He joined the BNS in 1956 and acted on a number of occasions as Chairman of the Publications Committee. Although his main research was in plant physiology on nitrogen metabolism and respiration, he was active in plant ecology, notably in studies of the vegetational history of the Gordano Valley, the development of the Berrow saltmarsh and the mineral nutrient regime of the dune system of Braunton Burrows, North Devon.

Names of contributors associated with several records, or with the determination of specimens, are abbreviated thus:

PJC	P.J. Chadwick	CK	Mrs C. Kitchen
NJC	Dr N.J. Chaffey	MARK	M.A.R. Kitchen
RSC	R.S. Cropper	ACL	Dr A.C. Leslie
IFG	Miss I.F. Gravestock	PJMN	P.J.M. Nethercott
DEG	D.E. Green	PGR	P.G. Rooney
IPG	I.P. Green	MJT	M.J. Trotman
PRG	P.R. Green	PW	P. White
DTH	Dr D.T. Holyoak		

BRISTOL BOTANY IN 1993

The area covered by this report is essentially that defined by J.W. White for his *Flora of Bristol* (1912). The eastern boundary is taken as the old boundary of Wiltshire where it meets the old boundaries of both Gloucestershire and Somerset. The southern limit is taken as approximately the course of the River Brue along some of its length. The area comprises the northern part of the Watsonian vice-county of North Somerset (v.c. 6) and the southern part of West Gloucestershire (v.c. 34). In the following records these parts are designated S and G respectively.

Many plant names are in accordance with C. Stace *New Flora of the British Isles*, 1991.

Equisetum × *litorale* Kühl. ex Rupr. (*E. fluviatile* L. × *E. arvense* L.) With both parents, damp grassland, Priddy, S and also pool near lead-mine spoil, near Charterhouse, S, DTH.

Dryopteris carthusiana (Villars) H. P. Fuchs Single clump, Marsh Wood, west of Oakhill, S, PRG.

Ophioglossum vulgatum L. Numerous plants, Bradley Green, Wotton-under-Edge, G, MJT. A few plants in damp part of field, Henton, S, IPG; elsewhere in the field were *Oenanthe lachenalii* C. Gmelin, *Centaurium pulchellum* (Sw.) Druce, *Ophrys apifera* Hudson and *Spiranthes spiralis* (L.) Chevall.

Aconitum napellus L. Several fine clumps, Coleford, S, RSC; also *Myosotis scorpioides* L., *Cirsium dissectum* (L.) Hill, *Dactylorhiza maculata* (L.) Soó, *Carex acutiformis* Ehrh. and *C. panicea* L.

Clematis vitalba L. var. *integrata* DC. Rare, among normal-leaved climbers, Wick Rocks, G, PJMN. Recorded for Clifton Down (H.J. Riddelsdell *et al.*, *Flora of Gloucestershire*, 1948, p.1) but not elsewhere in the Bristol area.

Ranunculus arvensis L. In good quantity, on disturbed land, Tracy Park, near Wick, G, MARK & CK.

Fumaria bastardii Boreau Several plants, north bank of River Brue, Highbridge, S, ACL.

F. muralis Sonder ex Koch ssp. *boraei* (Jordan) Pugsley Several along roadside verge, Huntspill Moor, S, RSC; also *Chenopodium ficifolium* Smith.

Cakile maritima Scop. One plant on wall, West Huntspill, S, RSC.

Cochlearia × *hollandica* Henrard (*C. anglica* L. × *C. officinalis* L.) Plentiful near both parents at edge of saltmarsh near Sand Point, S, DTH.

Draba muralis L. On stone wall, Ashwick, S, Mrs D. Maxwell.

Cardamine impatiens L. About fifty plants near car park, Cheddar Gorge, S, IPG, where not recorded since 1950.

Viola × *scabra* F. Braun (*V. odorata* L. × *V. hirta* L.) Several patches along lane sides near both parents, Tickenham Hill, S, DTH.

V. × *intersita* G. Beck (*V. riviniana* Reichb. × *V. canina* L.) Small patch adjoining both parents, Draycott Sleights Nature Reserve, Rodney Stoke, S, DTH.

V. palustris L. Still in good quantity on Blackdown, S, RSC. Persistent and flowering sparingly, Downhead Common, S, RSC; also *Luzula multiflora* (Ehrh.) Lej., several plants of *Carex binervis* Smith, and in old quarry a plant of *Myosotis discolor* Pers.

Hypericum × *desetangsii* Lamotte (*H. perforatum* L. × *H. maculatum* Crantz) Small patch in sloping grassland near edge of wood, Priddy, S, DTH.

H. montanum L. In moderate numbers, rocky coastal fringe, Margaret's Bay, near Portishead, S, and a single plant on cliff top, Walton Cliff, Clevedon, S, MARK & CK.

Helianthemum apenninum (L.) Miller In very small quantity, with many naturalized species, at site of former cottage, Sand Point, S, MARK & CK. This plant has been known here since 1984.

Sagina nodosa (L.) Fenzl Very plentiful in disused quarry, Doulting, S, PRG.

Atriplex littoralis L. A small population, west shore of Stert Island, S, and plentiful on edge of weedy field, Brean, S, PRG.

Salicornia dolichostachya Moss Abundant on bare mud, Woodhill Bay, Portishead, S, MARK & CK. This Glasswort is persistent here, being last reported nearly forty years ago (*Bristol Botany in 1956*, p. 184).

Lavatera arborea L. Two plants at roadside, Crook Peak, S, RSC; also *Melilotus albus* Medikus.

Althaea officinalis L. Three good seeding plants, Redcliff Bay, near Portishead, S, MARK & CK. Last reported from here in 1970 (*Bristol Botany in 1970*, p. 16).

Erodium maritimum (L.) L'Hér. In substantial quantity, at top of coastal cliff (Carboniferous limestone), St. Thomas's Head, S, MARK & CK.

Hippocrepis comosa L. Plentiful in a very few compact colonies on Wavering Down and Crook Peak, but absent from large areas apparently suitable for its growth. S, PJMN.

Vicia bithynica (L.) L. A plant, in tipped rubble, Tracy Park, near Wick, G, MARK & CK.

Potentilla neumanniana Reichb. A small colony in thin turf above disused quarry, Leigh-upon-Mendip, S, J. Poingdestre.

Rosa obtusifolia Desv. A single bush, with much *R. stylosa* Desv. and *R. arvensis* Hudson nearby, on grassy slope above valley bottom, Coleford, S, RSC; also *Lathyrus linifolius* (Reichard) Baessler and *Platanthera chlorantha* (Custer) Reichb.

Prunus × *fruticans* Weihe (*P. spinosa* L. × *P. domestica* L.) Bush in hedgerow, just east of Burrington Combe, S, DTH.

Chrysosplenium alternifolium L. Small patches by stream bank and on small islands in the stream, Tyley Bottom, near Wotton-under-Edge, G, MARK, CK, P. Jackson & Miss K. Hill.

Ribes alpinum L. Tor Hill, Wells, S, Miss V. Copp.

Daphne laureola L. A few bushes in hedgerow, Stoodly Hill, Pilton, S, and one bush near track, Mendip Lodge Wood, S, RSC.

Epilobium lanceolatum Sebast. & Mauri Abundant, disused mine, Pensford, S, J. Rees. Plentiful on spoil heap, Chilcompton, S, and edge of Moons Hill Quarry, Stoke St. Michael, S, PRG.

E. roseum Schreber A few plants, roadside, Chilcompton, S, and two plants, Great Gains Wood, Cranmore, S, IPG.

Eryngium campestre L. Several plants, two flowering, in grass in plantation of young ash, Hinton Charterhouse, S, RSC. This site is near that where the plant has persisted for a considerable time, as reported in *Bristol Botany in 1983*, p. 67.

Berula erecta (Hudson) Cov. With *Mentha* × *piperita* L., streamside by road, Norton-St-Philip, S, PRG.

Oenanthe lachenalii C. Gmelin Plentiful, with *Ononis spinosa* L. and *Serratula tinctoria* L., near to the site reported in 1894 (Barrow Hill, R.P. Murray, *Flora of Somerset*, 1896, p. 166), in unimproved damp pasture, Great Elm, S, PRG.

Euphorbia platyphyllos L. Eight fruiting plants in cereal field, Mill Hill, Golden Valley, Bitton, G, MARK, CK, S. H. Bishop, NJC & H. J. Killick.

Rumex × *pratensis* Mert. & Koch (*R. crispus* L. × *R. obtusifolius* L.) Single plant on steep bank, with both parents, Leigh-upon-Mendip, S, PRG, conf. IPG.

R. × *dufftii* Hausskn. (*R. sanguineus* L. × *R. obtusifolius* L.) One plant near large numbers of both parents, slopes above cliffs, Clevedon, S, DTH.

R. × *steinii* A. Becker (*R. obtusifolius* L. × *R. palustris* Smith) Three plants, near both parents, Shapwick Heath National Nature Reserve, S, DTH & G. A. Griffiths, conf. Dr J. R. Akeroyd. This is a first record of this hybrid for v.c. 6.

R. pulcher L. Frequent in rough grassland, Purn Hill, Bleadon, S, and also a single plant on ramparts of hill fort, Cadbury Camp, Tickenham, S, RSC.

R. × *schulzei* Hausskn. (*R. crispus* L. × *R. conglomeratus* Murray) One very infertile plant, near large numbers of both parents, rough grassland adjoining saltmarsh, west of Clevedon, S, DTH.

R. × *ruhmeri* Hausskn. (*R. conglomeratus* Murray × *R. sanguineus* L.) Near plentiful *R. sanguineus* on slopes above cliffs, Clevedon, S, DTH. Also, with both parents, two plants on slope of Nyland Stone, Draycott, S, PRG, conf. IPG.

Parietaria judaica L. With *Rhamnus cathartica* L., a colony over several square metres on and near a rockface, Compton Hill, Compton Bishop, S, PJMN. Pellitory is more usually found on old walls, rubble tips etc., more rarely on rock.

Salix purpurea L. Road verge, probably planted, Bleadon, S, PRG.

S. × *fruticosa* Doell (*S. viminalis* L. × *S. aurita* L.) Near pond, Downhead, S, PRG.

Limonium vulgare Miller Three fairly large patches, where known for several years, saltmarsh, Woodhill Bay, Portishead, S, MARK & CK. In the *Flora of Bristol*, 1912,

p. 498, J.W. White reports this plant from the Battery Point, Portishead, but as 'Now lost'.

L. binervosum (G.E. Smith) Salmon In moderate numbers among rocks, Battery Point, Portishead, S, R .D. Randall & MARK.

Centaurium erythraea Rafn × *C. pulchellum* (Sw.) Druce Several plants with both parents, cliff slopes, north-east of Clevedon, S, DTH.

Menyanthes trifoliata L. Small clump, Inglestone Common, G, I. Ralphs.

Verbascum nigrum L. Several plants in grass verges, Marshfield, G, PJC & J. D. R. Vernon.

Melampyrum pratense L. By path, Magg's Wood, Coleford, S, PW.

Thymus pulegioides L. A large patch, Cadbury Camp, Tickenham, S, RSC; also *Rubia peregrina* L.

Clinopodium ascendens (Jordan) Samp. Rare on low cliffs above saltmarsh, St. Thomas's Head, S, MARK & CK.

C. acinos (L.) Kuntze A few plants, hedges of small disused quarry, Priddy, S, PRG.

Stachys × *ambigua* Smith Patch on railway bank, Great Elm, S, PRG.

Marrubium vulgare L. Small colonies, Cross Plain, near Axbridge, S, and Compton Hill, Compton Bishop, S, PJMN. Commoner and long known on Wavering Down between these hills.

Scutellaria minor Hudson A small flowering clump, Rodway Hill, near Mangotsfield, G, MARK & CK. Flowering followed the clearing of brambles last year (*Bristol Botany in 1992*, p. 30); further clearing by MARK & CK has been undertaken to free *Hypericum elodes* L., not seen in 1992 and not flowering this year. Also Lower Woods, Selwood, S, PRG. Single plant, Marsh Wood, Croscombe, S, PW.

Plantago coronopus L. Plentiful in short turf in road verges, Bleadon, S, PRG.

Campanula latifolia L. A good patch, with single plants not far away, adjoining the River Boyd between Bitton and Wick, G, MARK, CK, S. H. Bishop, NJC & H. J. Killick. The Great Bellflower is rare in the Bristol region, being previously recorded only in the Frome valley and Vallis Vale, where still present in fairly large numbers, IPG.

Galium × *pomeranicum* Retz. (*G. verum* L. × *G. mollugo* L.) Small patch in grassland, Wain Hill, Clevedon, S, DTH.

G. pumilum Murray Very scarce in short grassland, Dolebury Warren, S, DTH.

Valerianella carinata Lois. At foot of wall, Stoke Bishop, Bristol, G, IFG.

Dipsacus pilosus L. In small quantity, Tyley Bottom, near Wotton-under-Edge, G, MARK, CK, P. Jackson & Miss K. Hill. Several plants, old quarry, Leighton Hanging, S, RSC; also *Epilobium lanceolatum* Sebast. & Mauri and several patches of *Hypericum maculatum* Crantz at edge of quarry and in disturbed grassland.

Succisa pratensis Moench Plants with flesh-coloured flowers near towpath below Leigh Woods, Avon Gorge, S, PJMN. This colour variation is known elsewhere in the Bristol area (J.W. White, *Flora of Bristol*, 1912, p. 363).

Senecio × *albescens* Burb. & Colgan (*S. cineraria* DC. × *S. jacobaea* L.) Wall, Chapel Allerton, S, IPG.

Filago minima (Sm.) Pers. Over a dozen plants, disused mine, Pensford, S, G. Stone.

Cirsium dissectum (L.) Hill Damp field adjoining Mells stream, Coleford, S, PRG.

C. × *forsteri* (Smith) Loudon (*C. dissectum* (L.) Hill × *C. palustre* (L.) Scop.) One plant, near both parents, marshy field, Weston Moor, Gordano Valley, S, DTH.

Onopordum acanthium L. Seven flowering plants, with many rosettes, rough meadow, Walton Moor, Gordano Valley, S, RSC; also *Verbascum virgatum* Stokes, a single plant of *V. nigrum* L., *Danthonia decumbens* (L.) DC. and plentiful *Vulpia bromoides* (L.) Gray.

Butomus umbellatus L. Abundant, perhaps planted, banks of large new extension to pond near banks of the Severn, Berkeley saltmarsh, G, MARK.

Zostera angustifolia (Hornem.) Reichb. Two small rooted patches on river gravels in the Severn, a considerable distance from the river's edge, Severn Beach, G, R. Higgins & J. Martin. Examination of the area nearby by MARK & CK shortly after this find showed the presence of about 15 colonies, 0·5 - 2 m^2, on slightly raised sandy banks beyond a shingle ridge, spreading over at least 70 m north to south, conf. Dr N.T.H. Holmes. These are the first records of *Z. angustifolia* for v.c. 34. The related *Z. marina* L. was first certainly recorded from v.c. 34 from the mud-flats off Middle Point Breakwater opposite Slimbridge in 1937 by O. H. Wild (H. J. Riddelsdell *et al.*, *Flora of Gloucestershire*, 1948, p. 495).

Polygonatum odoratum (Miller) Druce A patch on oolitic scrubbed-over grassland at edge of wood, Sheep Path Wood, Dursley, G, MARK, CK & J. Smallwood. This locality may be that given by H.J. Riddelsdell *et al.*, *Flora of Gloucestershire*, 1948, p. 467, as 'Stinchcombe Hill, bare slopes'.

Juncus compressus Jacq. A patch of about 1 m^2, Inglestone Common, G, MARK & CK. Previously reported here (*Bristol Botany in 1940*, p. 90), but rather seldom recorded in v.c. 34.

J. foliosus Desf. On Blackdown, east of Tyning's Farm, Mendip, S, in 1992, IPG, a first record of this taxon, formerly included under *J. bufonius* L., for v.c. 6. The plant was fairly plentiful, scattered in a marshy area alongside a very small stream in a field, with *Eriophorum angustifolium* Honck., *Juncus bufonius* L., *sensu stricto, J. bulbosus* L. and *Potamogeton polygonifolius* Pourret. In 1993, many vigorous plants in green lane, West Huntspill, S, RSC; also igood quantity at pool margin, with *J. ambiguus* Guss., Berrow, S, RSC. Frequent on edge of muddy ditch, Downhead, S, PRG.

J. maritimus Lam. A small patch in saltmarsh, Woodhill Bay, Portishead, S, MARK & CK. This site appears to be further west than the long-standing record by Rev. E. Ellman of 'several clumps ... north of Portishead Pill' (*Bristol Botany in 1915 and 1916*, p. 201).

Iris foetidissima L. Very sparingly, Bourton Combe, S, PJMN.

Cephalanthera damasonium (Miller) Druce Under beech, Lyncombe Vale, S, RSC, where flowering was the best known since 1976.

Epipactis purpurata Smith Poorly flowering this year, Hunstrete Lake, S, RSC, where also two large flowering patches of *Nymphoides peltata* Kuntze.

Neottia nidus-avis (L.) Rich. Under trees, King Castle Wood, Dulcote, S, C. J. Cornell & Miss V. Copp. Under beech, Engine Wood, South Stoke, S, RSC, and also in shaded area a little to the north.

Ophrys apifera Hudson Flowered freely on banks of the Long Ashton By-pass, S, and especially prolific (well over 3,000 flower spikes) at Aust, G, where it has spread over 250 m of the bank, PJC.

Orchis morio L. Four small plants, Middle Hope, S, MARK & CK. The Green-winged Orchid has previously been recorded from the south side of Sand Point (*Bristol Botany in 1977*, p. 24), but has decreased in many places in the British Isles in recent decades.

Anacamptis pyramidalis (L.) Rich. Flowering sparsely at Dodington Ash and in Cribbs Causeway area, but much more freely at Battlefields and the West Littleton Down area, all G, PJC.

Typha glauca Godron (*T. latifolia* L. × *T. angustifolia* L.) Worle, S, sent to IPG, det. ACL. This is a new record for v.c. 6.

Eriophorum angustifolium Honck. A single flowering spike, boggy flush, Coleford, S, PW & PRG; also *Anagallis tenella* (L.)L. and *Triglochin palustre* L.

E. latifolium Hoppe Eighty fruiting heads, the highest count in the last twenty years, Max Bog, Winscombe, S, RSC.

Isolepis cernua (Vahl) Roemer & Schultes In very small quantity, Charlcombe Bay, between Clevedon and Portishead, S, MARK & CK. Formerly known in this vicinity (*Bristol Botany in 1971*, p. 101).

Cyperus longus L. Large stand in ditch by road, where probably discarded, Bleadon, S, PRG.

Carex extensa Gooden. One small clump, Redcliff Bay, near Portishead, S, MARK & CK. Reported between Portishead and Walton Bay (*Bristol Botany in 1924*, p. 177) but very scarce in this part of the coast, in contrast to the plentiful *C. distans* L.

C. lasiocarpa Ehrh. A few flowering spikes, Catcott Heath, S, RSC, where not seen in flower since 1980. Also still present, but not flowering, Street Heath, S, RSC.

C. elata All. A small patch with two fruiting spikes, but not flowering in 1991 or 1992, Max Bog, Winscombe, S, RSC.

C. pulicaris L. With *C. pallescens* L. and *Geum rivale* L., damp area by pond, Coleford, S, PRG; nearby was *Scutellaria galericulata* L. and *Veronica scutellata* L. Fruiting well in fen meadow, Walton Moor, Gordano Valley, S, RSC; also patch of *Geranium pusillum* L. by track.

Festuca arundinacea Schreber × *Lolium multiflorum* Lam. One plant in grassland with much *F. arundinacea* but little *L. multiflorum*, by Blagdon Lake, S, DTH.

Vulpia ciliata Dumort. ssp. *ambigua* (Le Gall) Stace & Auq. Persistent in fair quantity on small area of fixed dunes, Berrow, S, RSC; also *Trifolium scabrum* L., *T. arvense* L., *Orobanche minor* Smith and *Phleum arenarium* L.

Catabrosa aquatica (L.) P. Beauv. Muddy area adjoining stream, Downhead, S, PRG. Large patches at field border, Catcott Heath, S, RSC, and in rhine to the east.

Aira caryophyllea L. Abundant along the north edge of the Carboniferous limestone ridge between Middle Hope and St. Thomas's Head, S, MARK & CK. Also Ellenborough Park, Weston-super-Mare, S, RSC, and Burnham-on-Sea, S, RSC.

Calamagrostis epigejos (L.) Roth Two patches in coastal grassland, Margaret's Bay, between Clevedon and Portishead, S, MARK & CK. Very old records for this area are given by J.W. White, *Flora of Bristol,* 1912, p. 646.

Agrostis gigantea Roth Garden weed, Stoke Bishop, Bristol, G, IFG.

Alopecurus × *brachystylus* Peterm. (*A pratensis* L. × *A. geniculatus* L.) With both parents, damp hollow in field, Chewton Mendip, S, IPG, conf. Dr T. A. Cope.

Parapholis incurva (L.) C.E. Hubb. Plentiful in sandy area, Stert Island, S, Mrs D. Maxwell, IPG & PRG.

ALIENS

Anemone apennina L. Well naturalized on wooded bank near Cleeve Court, Goblin Combe, S, RSC.

Berberis × *stenophylla* Lindley One bush persisting on scrubby roadbank near seawall, Uphill, S, DTH.

Papaver orientale L. A few plants, slope above cliff, Clevedon, S, DTH. Several specimens, field bank south of Mascall's Wood, Cheddar, S, PRG.

Pseudofumaria alba (Miller) Liden Plentiful on gravestones, churchyard, Chapel Allerton, S, IPG.

Hirschfeldia incana (L.) Lagr.-Fossat Single plant by wall, roadside, West Horrington, S, IPG, and plentiful in quarry, West Horrington, S, PRG & IPG.

Iberis umbellata L. Abundant, Breakheart Quarry, Dursley, G, MARK & CK, conf. E. J. Clement.

Barbarea verna (Miller) Asch. Several plants at foot of wall, Coleford, S, PRG.

Lychnis coronaria (L.) Murray Small patch on bank, Clevedon Court Wood, S, DTH.

Agrostemma githago L. In two spots, cleared ground, Draycott Sleights Nature Reserve, Rodney Stoke, S, I. & Mrs J. Burfield.

Lavatera thuringiaca L. Well established patch on roadside, Wedmore, S, DTH.

Geranium × *oxonianum* Yeo (*G. endressii* Gay × *G. versicolor* L.) Garden throw-out, edge of scrub, Berrow, S, ACL.

Oxalis articulata Savigny Flowering patch on roadside bank, East Wood, Portishead, S, MARK & CK. The Pink-sorrel is a rather common garden escape around Bristol, but has not been previously recorded here.

Impatiens parviflora DC. Plentiful, Dag's Lane, Chewton Mendip, S, IPG & Miss G. A. Crouch. Road bank, Mells, S, IPG, and roadside, Buckland Down, Buckland Dinham, S, IPG.

I. glandulifera Royle With *Carex pendula* Huds., by river at Boyd Bridge, Wick, a mile lower downstream from the Wick Rocks record (*Bristol Botany in 1988*, p. xxix), G, PJMN. Abundant on both sides of the River Avon, Swineford, G & S, RSC.

Vicia villosa Roth In good quantity, Tracy Park, near Wick, G, MARK & CK.

Rubus phoenicolasius Maxim. Large patch on roadside bank, north-east of Sidcot, S, DTH.

Cotoneaster integrifolius (Roxb.) Klotz One bush persisting on scrubby bank adjoining seawall, Uphill, S, DTH. On rocky slopes in open grassland, Burrington Combe, S, RSC.

C. simonsii Baker One large bush, Worle Hill, S, RSC; also *Anchusa arvensis* (L.) M. Bieb. and a single plant of *Oenothera glazioviana* Micheli ex C. Martius.

C. rehderi Pojark. Olveston, G, PGR, conf. Mrs J. Fryer.

Pyracantha coccinea M. J. Roemer One well-established shrub, The Gully, Clifton Down, Bristol, G, PJMN; one bush previously known in Leigh Woods (*Bristol Botany in 1959*, p. 16). One bush on rocks of small old quarry, Church Hill, Clevedon, S, DTH.

Sorbus intermedia (Ehrh.) Pers. Four young trees scattered through woodland, presumably bird-sown, Worlebury Hill, Weston-super-Mare, S, PJMN.

Crassula helmsii (Kirk) Cockayne With *Myriophyllum aquaticum* (Vell. Conc.) Verdc., pond, Hanham Green, G, DEG, probably discarded by aquarists. Pond, dune slack, Berrow, S, IPG.

Oenothera cambrica Rostanski Several plants, waste ground where persistent over a number of years, Wick Rocks, G, PJMN. On tip, Tracy Park, near Wick, G, MARK & CK. Fixed dunes, Berrow, S, RSC.

Ammi majus L. A single plant, market garden, Bromley Heath, G, MJT; also one plant of *Nicandra physalodes* (L.) Gaertner.

A. visnaga (L.) Lam. One plant at edge of reservoir, Herriott's Bridge, Chew Valley Lake, S, DTH.

Persicaria amplexicaulis (D. Don) Ronse Decraene Small patch, grassy slope, Burrington Combe, S, DTH.

Fallopia baldschuanica (Regel) Holub Well established, coastal cliff-tops, Battery Point, Portishead, S, MARK & CK.

F. sachalinensis (F. Schmidt ex Maxim.) Ronse Decraene   Patch by old quarry, Cleeve, S, DTH.

Quercus cerris L. × *Q. robur* L.   One sapling near both parents, Walton Common, Gordano, S, DTH.

Q. rubra L.   Planted, Battlefields Wood, Cranmore, S, PRG.

Symphytum grandiflorum DC.   Plentiful along lane, Chewton Mendip, S, PRG.

Trachystemon orientalis (L.) Don   Fruiting in good quantity in woodland north of railway line, Sneyd Park, Bristol, G, PGR & T. N. Twiggs.

Datura stramonium L.   Two plants on site of new building, Brean, S, PRG.

Verbascum blattaria L.   One plant on industrial estate, Glastonbury, S, Mrs P. Poingdestre.

V. densiflorum Bertol.   Two plants on disturbed ground in ride, Clevedon Court Woods, S, DTH.

Campanula portenschlagiana Schultes   Well naturalized on walls, Portishead, S, MARK & CK; also *C. poscharskyana* Degen.

Sambucus racemosa L.   Single tree, Postlebury Wood, Wanstrow, S, Mrs G. Read. This is the first record for v.c. 6 of the Red-berried Elder.

Leycesteria formosa Wallich   One bush on bank of the Severn, Redcliff Bay, S, MARK & CK.

Doronicum pardalianches L.   Roadside verge, Bradley Green, Wotton-under-Edge, G, MJT.

D. × *excelsum* (N. E. Br.) Stace (*D. plantagineum* L. var.*excelsum* (N. E. Br.)   Roadside, Leigh-upon-Mendip, S, Mrs G. Read & R. A. Barrett, conf. IPG.

Conyza sumatrensis (Retz.) E. Walker   One plant, with *C. canadensis* (L.) Cronq. and plentiful *Cynodon dactylon* (L.) Pers., by bridge over railway, Weston-super-Mare, S, IPG; also in flower borders and waste areas along sea front over a considerable distance, and nearby. Single plant in crack in pavement, Burnham-on-Sea, S, IPG.

Carthamus tinctorius L.   Several plants from bird seed, north bank of River Brue, Highbridge, S, ACL; also *Guizotia abyssinica* (L.f.) Cass.

Lagarosiphon major (Ridley) Moss   In recently restored village pond, The Barton, Hawkesbury, G, DEG; presumably a throw-out by aquarists. In 1990 in pool, Berrow, S, IPG. A small patch in recently-cleared pool there, noted in December 1992, was much increased in 1993, RSC; the plant is now common in several pools, IPG.

Allium carinatum L.   Patch in grassland on slope above cliffs, Clevedon, S, DTH.

A. roseum L.   Two small colonies on ledges of old quarry, Cleeve, S, DTH.

Nectaroscordum siculum (Ucria) Lindley   Abundant by footpath and in adjoining orchard, Bradley Green, Wotton-under-Edge, G, MJT & P. Smith.

Hermodactylus tuberosus (L.) Miller Large stand on sandy road verge, Berrow, S, PRG. This is the second record for v.c. 6.

Crocosmia × *crocosmiiflora* (Lemoine ex Burb. & Dean) N.E. Br. Well established scattered colonies, wooded edge of Kewstoke Road, Weston-super-Mare, S, PJMN.

Lemna minuta Kunth In ditches, Weston Moor, Gordano Valley, S, DTH. Also disused canal, Coleford, S, DEG.

Bromopsis inermis (Leysser) Holub Large patch on ledge of quarry, Cheddar, S, PRG.

Anisantha diandra (Roth) Tutin ex Tzvelev A few clumps, waste ground, near Railway Station, Weston-super-Mare, S, NJC, conf. PGR. Plentiful on manure heap in field, Chapel Allerton, S, IPG.

Gaudinia fragilis (L.) P. Beauv. Abundant on grassy south-facing slopes, Uphill, S, NJC, det. MARK & PGR; also *Trifolium scabrum* L. and *T. striatum* L.

Phalaris arundinacea L. var. *picta* L. A garden escape in lane, Stoke Bishop, Bristol, G, IFG.

P. aquatica L. Plentiful, sea wall, West Huntspill, S, IPG.

Pseudosasa japonica (Siebold & Zucc. ex Steudel) Makino ex Nakai This Bamboo was adjoining wall, Harridge Wood, Oakhill, S, PRG, det. ACL. Also small patch in trees by old ruin, Stratton-on-the-Fosse, S, PRG.

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LOWER WETMOOR WOOD - AN INTRODUCTION

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INTRODUCTION

The 300 hectares (750 acres) of ancient woodland known as the Lower Woods lie about 16 km (10 miles) north-east of Bristol, athwart the Little Avon River which here divides the parishes of Hawkesbury and Horton. The Lower Woods were designated as a Site of Special Scientific Interest in 1966 and re-designated in 1985 under Section 28 of the Wildlife and Countryside Act, 1981.

Lower Wetmoor Wood covers 13 hectares (32 acres) in Horton parish, at the heart of the Lower Woods. It forms the major part of the Gloucestershire Wildlife Trust's Wetmoor Reserve, which was acquired in 1967 with the help of the World Wildlife Fund, because it holds the last intact oak-woods in the Vale of Berkeley. The reserve also includes Little Bath Riding (2.4 ha or 6 acres) which adjoins Lower Wetmoor to the north-west, and Mossy Wood (4.9 ha or 12 acres) which lies nearer the south-western edge of the Lower Woods.

Lower Wetmoor is the subject of the two papers following this one. As a prelude to these, and to others which may appear, we give here some background in the form of notes on the past importance of woodlands and on the general nature of coppice management, followed by an outline of the known history and past management of the Lower Woods. Finally we give some account of Lower Wetmoor, which has already figured in two papers in these *Proceedings* (Patrick & Hendry, 1984; Hendry *et al.*, 1988). Another *Proceedings* paper relevant to the Lower Woods is by Penistan (1988).

WOODLAND AS A HUMAN RESOURCE

It is difficult today to appreciate the importance of woodland products for rural life in the millenia before the industrial revolution, when they provided both essential raw materials and the only available source of energy. Hazel, maple, ash, oak and willow provided: fences, made from stakes with rods woven amongst them; hurdles, for enclosing sheep and cattle; posts to support house walls, beams and rafters for roofs and wattle panels to fill in between the posts; wands and spars for thatching roofs and ricks; rakes, pitchforks, shovels and tool handles; baskets, panniers and barrel hoops;

chairs and stools; platters, bowls and spoons; clogs; and much more. Brushwood made besoms, but principally faggots to fuel bread ovens or, buried in rows, to act as field drains. Charcoal fuelled the blacksmith's forge, and oak bark was essential for tanning leather.

Most of these products did not come from **timber** - the trunks and major branches of mature trees - but from poles (over about 5 cm in diameter), rods (thinner than poles) and brushwood, all cut from the shrub layer or **underwood**. Indeed, woods came to be valued according to the average yield of their underwood, and by 1270 an acre of underwood gave a greater return than an acre of arable land (Rackham, 1986). Woodland management was geared to providing a sustainable source of these materials, by exploiting the fact that many broad-leaved trees throw up new shoots from the stumps left after felling. Evidence from wooden trackways preserved in the peat of the Somerset Levels shows that man has utilised this fact for over 5,000 years (Coles, 1986). In the words of Rackham (1990, p.38), 'Early Neolithic people had already made the discovery which is the key to woodland management: that the regrowth shoots from a stump are more useful than the original tree.' The procedure is described in the next section, in terms of an oak-ash woodland like the Lower Woods.

COPPICING

BASIC PROCEDURE

An extensive tract ofwoodland would be subdivided into a number of sections. The underwood, typically hazel, maple, ash and oak, would be cut in rotation, one section each winter. The work of cutting the underwood to just above ground level would be shared among men from the manor or parish, each allocated his 'cant' of an acre or so. The cut area would then be enclosed for several years until the tender tips of the new shoots were too tall to be browsed by cattle or deer. The inclosure or coupe (Norman-French *couper*, to cut) would then be re-opened to the animals of those holding grazing rights until the turn came round for this section to have its underwood cut once more. This was the process of **coppicing**. Trees or bushes repeatedly treated in this way form **stools** which throw up many shoots. Barring some disaster, stools can survive indefinitely under this treatment. They continue to grow outwards, but very slowly (making narrow annual rings) so that a sizeable oak coppice stool may be hundreds of years older than a standard tree of the same basal diameter.

In earlier times there might have been from five or six up to ten or so coupes involved in the rotation. As the system developed, many coupes came to be permanently defined by **woodbanks** - earth banks topped by hedges, and with a ditch outside. In time the basic procedures were fixed by laws, like one of 1543 (Statutes of the Realm 34-5 Hen. VIII c. 3) that penalised failure to fence woods after coppicing and specified a minimum number of standards per acre.

To provide more substantial timber for the posts, beams and rafters of ordinary buildings and for other purposes, coppice stems of oak or ash would be allowed to grow through several cycles of underwood coppicing, perhaps for 25 to 50 or more years - in Derbyshire poles destined for pit-props needed 25 years of growth (Fairey, 1818, cited by Peterken, 1993). Sometimes most of the shoots on a stool were removed to promote the growth of the remaining one or few (the process of 'singling').

Along with this relatively short-term cycle of underwood cutting and regrowth went another, much longer cycle. In most woods some oaks were not coppiced but were left as standards growing on to maturity, perhaps for 200 years, to provide major timber and a supply of acorns for pigs and, with luck, for regeneration. This type of woodland is known as coppice-with-standards. In earlier times it seems that timber was cut as needed, the carpenters choosing the smallest trees that would meet their needs. Later it became the practice, each time the underwood was cut, to cull some standards from each age group, retaining the best; enough saplings were left to form eventual replacements. After a long period of this management, all age classes of standard trees, from saplings to maturity, would be present.

The underwood produce was distributed to the parish right-holders or sold in the nearby towns, but the standards trees - oak in the Lower Woods - belonged, like the land, to the Lord of the Manor and would be used in the construction, extension or repair of substantial buildings - major churches, tithe barns, monastic halls, manor houses or colleges, whose construction would require many hundreds of trees. Such oak survives today as large construction members in many important buildings dating from the middle ages. The largest, straightest standards would be needed as the central supporting posts of the ubiquitous windmills.

Many ordinary dwellings and farm buildings were also built on oak frames, which would need typically more than a hundred stems each. These would have mainly used coppice stems, or branches from standards, rather than standard trunks, and would often have been used complete with their sapwood, which is less durable than heartwood, and subject to insect attack - perhaps the chief reason why so few of these buildings remain. Carpenters were adept at utilising curved and branched timber; a curved stem would often be cleft lengthwise to make two mirror-image members. Suitably sized stems would be chosen in the woods then cut, barked (in the case of oak) and sometimes roughly squared, ready for use (Venables, 1974).

Plate 1 shows coppice products used in a farmhouse built some 250 years earlier in an area where chestnut rather than hazel was the dominant underwood species in the oakwoods. The floor and ceiling of the main upper storey are each carried by three transverse beams about 5 m long and some 30 cm in original diameter, supporting 96 joists some 2 m long, derived from straight 50-60 year oak poles split or sawn into quarters. Many oak and chestnut poles of 20-30 years' growth were used as intermediate posts in the walls; between these were wedged hundreds of battens made from split chestnut and oak rods, the spaces being tightly rammed with clay mixed with twisted rush stems. The purlins and most of the rafters had been split from large, contorted oak branches. The four corner posts of the building are straight trunks of sessile oak, about 5 m long and 25 cm diameter, of 60-70 years' growth, with their bases tenoned into massive stones. The only members derived from more-or- less straight trunks are the six transverse beams. The upper floor was made in a similar fashion to the walls, with many short batons of cleft oak and chestnut fitted between the joists, the spaces between them being rammed with the clay-rush stem mixture. The ceiling of the upper storey was made of short oak planks some 3 cm thick and 15 - 25 cm wide, apparently split from stems of varying sizes, which carried an insulating layer of clay, 5 - 10 cm thick. Presumably this was an easier form of construction than that used for the floor, in view of limited headroom in the roof space. A barn added around 1875 has square-sawn oak roof timbers, clearly from a commercial timber yard.

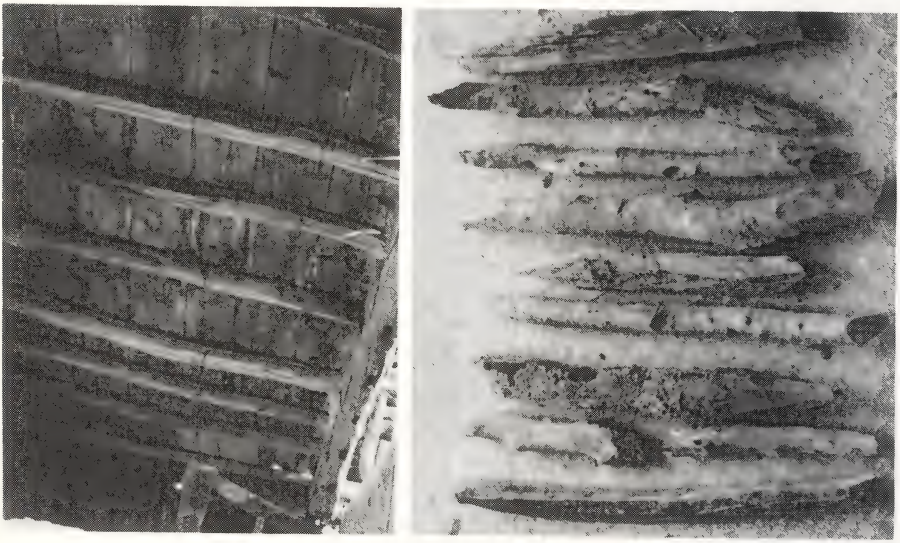

PLATE 1. Coppice materials from house built *c*.1725. Left, oak poles of *c*.30 years' growth, de-barked, supporting sloping ceiling of pine planks over stairwell. Right, oak, ash and chestnut batons from walls, of 5-10 years' growth: pointed end fitted in hole in one vertical post, wedge-shaped end in groove in next post.

The duration of the coppice rotation varied from place to place, according to the kind of product needed. Rackham (1990) mentions medieval wattle-and-daub wall panels, still in good condition after 500 years, showing seven to eight years' annual rings, while hazel wands to be woven into hurdles are best when seven to ten years old (Edlin, 1949). Occasionally, as in the aftermath of the Black Death, de-population might mean that a coppice rotation was abandoned either altogether or for a long period.

DEVELOPMENTS

From the sixteenth century rotations tended to become longer, implying a need for thicker, longer underwood poles. This must have meant an increase in the number of coupes by adding more woodland to the rotation. The coppice rotation in a particular place was not maintained with mathematical regularity. Local circumstances and variations caused by extremes of weather could mean that coupes were sometimes cut out of sequence. Also, some of the coupes could be in woodland detached from the rest. We can be sure, however, that in a typical rural community a cut was taken somewhere every year, for life depended on it.

From the seventeenth to the nineteenth centuries some coppiced woodlands were grubbed out and re-planted as plantations, while others were re-organised, with wide straight rides, often radiating from a central area. The coupes were laid out in a more regular and less haphazard way than formerly, and sometimes standard trees of additional species were planted.

DECLINE AND DEMISE

Economic changes in the nineteenth and early twentieth centuries reduced the demand for woodland products and so led to a decline of the labour-intensive coppicing system. The development of canals from the 1760s and of a railway network from the 1830s facilitated the long-distance movement of coal, building stone and bricks as well as the black country's growing output of iron fencing, gates and wire. All these reduced the demand for underwood for sale as a fuel in the towns, for fencing and for building.

In the nineteenth century a major factor was the development of coal-gas: every ton of coal distilled left about two-thirds of a ton of coke, a fuel more convenient and higher in calorific value than wood, whether for domestic and industrial boilers or for iron smelting and steel production. Coal-gas was used for factory lighting from 1798 and in a few London streets from 1808; its next street use seems to have been in 1811 when Mr Briellat installed gas lighting in his dyer's shop in Broadmead, Bristol and also in part of the street outside (Stone, 1908). In 1818 the Bristol Gas Light Company was launched, based at Temple Back, and in 1823 a rival company was started at Canon's Marsh. In 1862, by then amalgamated, they used nearly 48,000 tons of coal. In a few decades almost every town had its gasworks, giving a ready supply of coke. Demand was increased by the invention of the Welsbach incandescent mantle, which replaced flickering and smoky jets by brilliant, clean light; and the concomitant development of the prepayment (coin-in-slot) meter. Other uses were developed: the gas engine as an industrial prime mover from 1860, the ceramic fire element, and from 1892 the availability of domestic gas cookers on cheap hire. Even the advent of electric light in the 1880s did little to affect the demand for gas - in 1908 the Bristol company used 279,000 tons of coal, producing 186,000 tons of coke. The result of all this was that while in 1905 there were still coppice woods in almost every part of Britain, they had been virtually abandoned by 1965; most of what remained was chestnut, in the south-east, and some of this had already ceased to be worked regularly.

A coppicing regime dramatically changes the character of the underwood and revitalises the ground flora (Martin & Martin, 1995). Also, as there is always some area in every stage of growth a wide range of wild life habitats is available. The demise of coppicing therefore was very detrimental to the biological richness and diversity of much of Britain's woodlands. In recent years coppicing has been re-introduced on a small scale in a few woodland nature reserves, in order to restore habitat diversity.

HISTORY OF THE LOWER WOODS

The woods once formed part of **Kingswood Forest**, a royal hunting reserve since the tenth and perhaps the eighth century, which in Norman times included the whole Vale of Berkeley from the Little Avon to the Bristol Avon (Braine, 1891; Moore, 1982). It held much woodland, but the term 'forest' then meant an area containing deer, not an area containing trees. In it the king held the hunting rights, protected by special laws enforced by appointed officials, although he did not necessarily own the land; at their peak, royal forests covered about one-third of England. The forest laws greatly restricted commoners' rights; as an instance of their scope, we quote the following, cited by Linnard (1982) from the court roll of the Lordship of Ruthin for 12 August 1295:

Offence	*Fine*
cattle feeding in the forest	6d
cutting one tree	6d
cutting green wood in the forest	6d
carrying away old wood	6d
cutting down boughs for oxen	12d
cutting rods in the forest	6d
cutting and carrying away green wood	2s

Kingswood was disafforested - released from the forest laws - by King Henry III in 1228, in consideration of the huge sum of £150.

The Lower Woods lay in the northern part of Kingswood Forest, in the former Hundred of Grumbaldstone, now Hawkesbury and Horton parishes. The Saxons called the woods *Horwudu* (muddy wood), later Horwood, which has echoes in the present names of Horton parish and of Harwoodgate Farm on the edge of Sodbury Common. We have no details of Horwood's early boundaries. The Domesday survey of 1086 mentions a wood two miles long and a mile broad in Grumbaldstone Hundred, also other woodland in the present Horton, Little Sodbury and Old Sodbury which may once have formed part of Horwood. Much of this latter woodland has disappeared, but the main bulk in Hawkesbury and Horton survives today, apart from limited losses in the form of assarts (clearings for pastures) - e.g., Horwood Farm.

Saxton's map of Gloucestershire in 1577 shows Horwood lying athwart the Little Avon, as does Speed's of 1610, on which it is called 'Muddy Wood'. Isaac Taylor's 1777 map, to a scale of roughly one inch to a mile, also shows a sketchy outline, by then known as the Lower Woods (apparently in contrast to the Duke of Beaufort's woods on the Cotswolds). Beaufort Estate records show the area in detail around 1800, the individual woods being much as they are now. The first edition of the Ordnance Survey map in 1830 (based on a survey made in 1811) shows almost exactly the same outline as at present; Lower Woods Lodge is shown and the woods in both parishes are named 'Hawkesbury Woods'.

The individual woods are separated by wide, grassy rides known as **trenches**, at least some of which are thought to date from Norman times. They were once used for grazing, which would have kept down intruding scrub. At least one shows the remnants of a narrow stone trackway down the centre, made apparently with stones from the bed of the Little Avon. This is thought to have been made to ease the passage of pack animals bringing out underwood and, from the eighteenth century, sawn planks.

WOODLAND MANAGEMENT

Coppice-with-standards management must have existed here for many centuries, though details are lacking. Beaufort Estate records for the part of the woods north of the Little Avon, covering the period from 1770 to 1850, show that each was then coppiced either in a single winter or in two successive winters, individual woods being recut at intervals of 16 to 19 years.[1] A painting in Badminton House shows a meet of the Beaufort Hunt by the Little Avon in 1888. Shepherd's Knap, the grassy area descending to the Little Avon from the north-east, is portrayed as a sea of mud separated from the recently-coppiced East Stanley Wood by a laid hedge on a bank.

The Beaufort Estate maintained regular coppicing in these woods up to 1939 with the hedges being laid and the ditches kept open. The work occupied about twenty men. Increased wages costs, with low prices obtainable for the produce, the labour-intensive regular coppicing was not resumed after the 1939-1945 war, though some desultory coppicing by local inhabitants still continues (P. Parker, personal communication).

The best standard oaks were felled during the early 1940s for war-time needs; only some woods south of the Little Avon, including Lower Wetmoor, Mossy Wood and Little Bath Riding were spared, through the sheer difficulty of extracting the timber. Much of the lop and underwood from these fellings was used to produce charcoal.

In the southern part of the Lower Woods, across the Little Avon, the woods changed hands several times over the centuries and fewer details are known. However, the general management must have been similar over the whole area. After being clear felled during the 1939-1945 war, parts of Bays Wood and Stoneybridge Wood were later planted with spruce and other conifers. These grew only slowly on the heavy clay and needed to be freed repeatedly from competing shrubs and coppice shoots, so the project proved to be unprofitable. Another post-war scheme was the planting of hybrid poplars, destined as a source of matchwood, in the former coupes north of the river. Changing economic conditions ended this too, and mixed hardwoods are now being planted. The poplar stool beds set up close to Lower Woods Lodge have grown out into dense plantations.

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[1] Oak stems of *c.* 18 to 20 years growth were the preferred source of tanbark. At that age oak has a reasonable thickness of tannin-rich bast (inner bark) but only a thin layer of outer bark, which is almost tannin-free. A great expansion in use of leather from 1780 to 1850 increased the importance of tanbark, and much coppice was devoted to producing it (Rackham , 1986).

Since 1945 also, much of the open pasture of the Grubbings and Upper Wetmoor has become overgrown with birch, oak, poplar, aspen, hazel, buckthorn, hawthorn and blackthorn as the intensity of cattle grazing has lessened. Sparsely wooded areas are filling with impenetrable bramble and thorn scrub. Considerable natural oak regeneration has taken place both on Upper Wetmoor and in the war-time clearance areas; and extensive colonies of self-sown ash trees can also be found.

LOWER WETMOOR WOOD

The wood lies mainly on a fairly level plateau some 80 m (270 feet) above sea level, but its northern edge is a steep slope down to a narrow terrace bordering the Little Avon River at some 60 m asl. The soil is mainly a heavy poorly-drained clay, derived from the Lias. The dominant trees are English or pedunculate oak, which favours basic soil rich in mineral nutrients but tolerates water-logging, and sessile oak, which prefers the more acid and better drained soils in the south and west part. Hazel dominates the under-storey. Lower Wetmoor has been exploited for upwards of 1,000 years, but appears never to have been clear-felled. This, with the nature of its soils and its complex geology, makes it outstanding as ancient woodland and as a classical 'Damp Oakwood'. It falls into Type W8, 'ash-maple-dog's mercury' in the National Vegetation Classification (Rodwell, 1991).

Today, oak standards are present at a far higher density than usual for coppice-with-standards, and this has reduced the number of vigorous hazel coppice stools and killed many of the oak coppice stools (Taylor & Taylor, 1995). Not all the trees are oak; some tall ash, aspen and birch have grown up since the wood was last coppiced in 1929/30. Many ash stems on old coppice stools have also grown into substantial trees.

In 1969 the Wetmoor Reserve Management Committee introduced a regular coppice cycle on a small scale in part of the plateau area. The first rotation was completed in the winter of 1986/87. In the second rotation some coupe boundaries are being modified, to give a cycle of fifteen or sixteen years, and the coppiced area has been extended on the south up to the wood edge. Species such as primroses, violets, lesser celandine and pendulous sedge flower copiously in the early years after coppicing, but then flowering is inhibited by the deep shade cast by vigorously regrowing bramble, which in time is itself shaded out by the hazel and hawthorn (Martin & Martin, 1995). In 1987, to mark the twentieth anniversary of the acquisition of the Wetmoor Reserve, a nature trail was set up in the coppiced area.

The plant community comprises five layers: (i) the **tree or canopy layer**, predominantly of pedunculate oak, less commonly sessile oak, beech, ash, birch, wild service, alder, aspen and willow; (ii) the **shrub layer**, a well developed, often dense, understorey of hazel, hawthorn (both common and midland), field maple, dogwood, spindle and guelder rose; (iii) the **tall herb** vegetation, typically pendulous sedge, tufted hairgrass, giant fescue, meadowsweet and honeysuckle; (iv) the **field layer**, which often occurs in distinct societies depending on soil and light conditions, and includes bluebell, wood anemone, yellow archangel, dog's mercury, herb paris, woodruff, sanicle and hairy woodrush; and (v) the **ground flora** of mosses and liverworts, well developed in many parts.

These five layers are an integral part of the complex structure of the wood. A large number (22 species) of plants characteristic of primary woodland occur, confirming that the area has been continuously under woodland for many hundreds of years.

The thirteen hectares of Lower Wetmoor fall into four main areas: the river-terrace, the steep slopes rising from the river, the plateau forming the greater part of the wood and finally the rides. Taking each in turn:

(i) **The Little Avon River terrace** is the northern fringe of both Lower Wetmoor and Little Bath Riding for over 1 km. In places the terrace extends back from the river bank for as much as 20 m. Here are some fine groups of alder, mature willows, the finest ash trees and some introduced hybrid poplars. Hazel and to a lesser extent field maple are well developed and provide a densely shaded but beautiful walk in mid-summer. The field layer is at its most colourful in spring, with extensive colonies of golden saxifrage, ramsons, bluebells and fine stands of pendulous sedge. On the vertical river banks, swathes of the green thallose (strap-like) liverwort *Conocephalum conicum* are clearly visible; when bruised, it has a pleasant, rather oily smell. On the better drained sites of the terrace, dog's mercury and yellow archangel grow, though the latter rarely flowers in the deep shade. In places alluvial deposits rich in nitrogen and phosphorus support stands of cleavers, campions, cow parsley, nettle, lesser celandine, herb robert, cuckoo pint, wood avens, giant fescue and wood false brome. Undoubtedly this is the most varied and colourful area in late spring.

(ii) **The river valley slopes** extend for up to 100 m back from the river terrace. A combination of quite well-drained soil and open shrub cover allows the spread of extensive banks of bluebells, wood sorrel, violets and hairy woodrush. Primrose, bitter vetch, bugle and tufted hair-grass occur in the well-lit areas. Both ivy and honeysuckle are well established. Where the soil is alkaline, often with visible bands of limestone rag, sweet woodruff and wood sanicle may be found. Ferns, nowhere abundant, are confined chiefly to the well-drained areas. They include the male, lady and narrow and broad buckler ferns. Herb paris and early purple orchids grow nearby.

(iii) **The plateau** forms the greater part of Lower Wetmoor. Its vegetation shows little variation outside the area of the recent small coupes. Bramble, honeysuckle and the all-pervading ivy are common. Herb cover is sparse though readily visible in the monotony of the forest floor. Hard fern can be found on much of the plateau, an indicator of the acid soil conditions. Small colonies of lesser celandine, early and common dog violets and wood anemone are present. Wood sedge, valerian and barren strawberry make a weak show particularly near footpaths. Patches of tufted hair grass are found in the less shaded sites. Several daffodil colonies make an unusual mark on the otherwise dull ground flora; they have benefited greatly from the recent coppicing programme.

(iv) **The rides** are very much a 'disturbed' area, if only because they have to be kept free of encroaching shrubs and bramble. The wider a ride, the better developed is the flora; the majority of plant species are typical of wet soils and seem to thrive on the clay churned up by wellington boots and horses. Here are the very best stands of sedges, particularly pendulous and wood sedge. The remote sedge, common rush, tufted hair grass (often in fruit), meadowsweet, valerian, enchanter's nightshade, common tormentil, creeping jenny and yellow pimpernel can readily be seen, often in flower. The characteristic moss colonising the edges of hoof and boot prints is *Fissidens taxifolius*.

Lower Wetmoor is surrounded, except along the Little Avon, by an ancient woodbank some 2 km long; Excavations indicate that it was originally some 1.8 m high, with the outer ditch being some 0.5 m deep and 0.5 to 1.0 m wide (Hendry *et al*., 1984). The presence of this bank and the absence of any sign of a dividing bank within the wood shows that Lower Wetmoor was once a single year's coupe of a coppice system; though in the changing circumstances from the late eighteenth century onwards, comparison with the woods across the river suggests that it was large enough to have taken two winters to cut. A systematic layout of drainage ditches, some of which have been in part restored by the Reserve Management Committee, appear to date from the second half of the nineteenth century, and the straight main rides may have been cut then. This may also be when beech hedges were planted on some of the woodbanks, the likely source of a few large beeches, some of which show evidence of having been cut early in life. A few beeches well inside the wood probably originated as seedlings from the hedges. Records of the Beaufort and Liverpool estates show oak plantings in the Lower Woods around this period. While many oaks apparently dating from this time can be found in Lower Wetmoor, it is now clear that many others are regrowing, mostly as single stems, from coppice stools, some of which are very old indeed (Taylor & Taylor, 1995). Many large multi-stemmed ash trees have grown out from the stools last cut in 1929, and these are being re-cut as the second rotation progresses. Several tall aspen and birch have also grown up since Lower Wetmoor was last coppiced.

The heavy clay has always made it difficult to extract felled timber from Lower Wetmoor, particularly after wet weather. From the seventeenth century when the use of sawn planks came into fashion, the problem was eased by sawing the trunks into planks on the site. Sawpits were dug over which the felled trunks were manoeuvred on frameworks; two men would then saw the trunk lengthwise into planks, the senior pulling the saw from above, the other pulling from below in the pit. Two such pits were excavated during an archaeological study made in 1982-83 (Bannister *et al*.,

1984) and items found in one of them were dated to the period 1700 - 1770. The pits were some 3.5 m long, 1.0 m wide and 1.5 m deep; one has been preserved and fenced round. The survey also located a charcoal-burner's 'floor' in Lower Wetmoor near the river, though it could not be dated. Samples of charcoal fragments were found to be chiefly of oak and ash, with minor amounts of hazel and alder.

The weather takes its toll from time to time. The oaks were defoliated by frost on 3 May 1967, the coldest May on record. A cloud-burst on July 10th 1968 raised the Little Avon River by some three metres (10 feet) and swept away two footbridges; part of the meadow between Little Bath Riding and Lower Wetmoor slipped down the slope, the ravine carrying water from Upper Wetmoor was deepened and balls of clay up to 30 cm in diameter were swept down into the river. During the prolonged droughts of 1975, 1976 and 1989 the river flow fell to a trickle at times, and Wetmoor itself very nearly became dry.

ACKNOWLEDGEMENTS

The above account is a much-expanded version of part of the second edition of the Wetmoor Nature Reserve Guide, edited by S. M. Taylor and M. H. Martin (Gloucestershire Wildlife Trust, 1994). This in turn was an expanded version of the first edition (1980), edited by G. A. F. Hendry. Copies of the Guide, a Nature Trail leaflet and a Map with Notes are available from Gloucestershire Wildlife Trust, Dulverton Building, Robinswood Hill Country Park, Gloucester GL4 9SX. We thank Mr Alec Harding for the loan of copies of Braine (1891) and Stone (1908).

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APPENDIX

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THE OAKS OF LOWER WETMOOR WOOD (I)

by S. M. Taylor and M. V. Taylor

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INTRODUCTION

This is a first report on a continuing study of the oaks of Lower Wetmoor Wood (ST7487), the largest component of the Gloucestershire Wildlife Trust's Wetmoor Reserve which lies in Horton parish and near the centre of the Lower Woods, some 16 km north-east of Bristol. For many centuries Lower Wetmoor formed one component of a coppice-with-standards system involving probably the whole of the Lower Woods, but during the latter part of the last century it was converted into something nearer to high forest, although coppicing of the underwood continued at intervals of about 18 years up to around 1930. A small-scale coppicing programme was started in the central part of Lower Wetmoor in the winter of 1969/1970, and the second cycle was started in 1987/1988. Martin & Taylor (1995) give a general description of the wood and of the coppicing process, and in what follows acquaintance with this has been assumed. We are concerned here with the oaks in the areas coppiced between November 1987 and March 1994 (Fig. 1), referred to hereafter as the study area.

We embarked on the study with the aim of learning as much as possible about the ways in which past management practices have led to the structure of the wood as it is today. Key topics are the forms of individual oaks, their ages, their positions in relation both to one another and to other features, and variations in their rate of growth. We are concerned in this first account with the first two of these: the tree forms and their ages. Although our interest is in the oaks, we give some attention to the outgrown ash coppice stools and to the hazel coppice, because they throw light on past management.

METHODS

(1) In early spring, after completion of the winter's coupe, each tree in the study area is given an identifying number which is marked on a small cardboard label stapled to its bark. The tree's girth at breast height (bhg)[1] is measured with a steel tape, its physical form is noted with special reference to the shape and nature of its butt, and a rough assessment is made of the extent of epicormic shoots ("witches' brooms") present on its trunk.. Measurements with 33-metre fibre-glass tapes are used to determine the positions of the trees with respect to one another and ultimately with respect to nails driven into the tops of the stout oak posts which permanently mark the corner points of each coupe area. A few "datum" trees are marked by means of strong plastic tape tied round their trunks, so that they can be identified from a distance and from any direction. The tape is more permanent than the small card labels, and enables any tree

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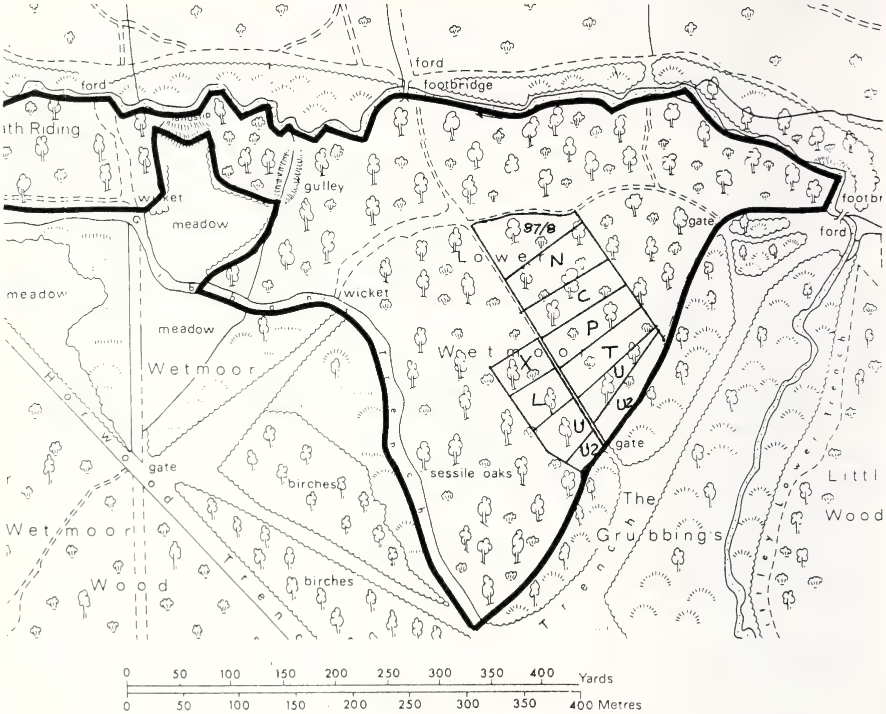
[1] Conventionally, at 1·3 m above ground level. Use of this height avoids interference from the root butttresses and from surrounding field layer vegetation, as well as much fatiguing stooping.


ford
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wicket
meadow
gulley
meadow
wicket
Lower Wetmoor
97/8
N
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gate
meadow
Wetmoor
gate
birches
sessile oaks
The Grubbings
Wetmoor Wood
birches
Trench
Little Wood
footbr
ford
0 50 100 150 200 250 300 350 400 Yards
0 50 100 150 200 250 300 350 400 Metres

Figure 1. Sketch map of Lower Wetmoor Wood, showing boundaries of the coppice coupes (the study area).

to be re-identified in a later season, should this be necessary, by reference to the nearest datum trees. Distances are measured at breast height between facing points on the bark of a pair of trees, and later adjusted by calculation to correspond to distances between tree centres. The corrections are calculated from the bhg values, assuming the tree cross-sections to be circular. Where a trunk is inclined so that its centre at breast height is noticeably displaced from the centre of the butt, the details are recorded so that the position of the butt centre can be mapped. Photographic records are made of trees showing special features.

(2) When oaks are felled - a rare event - a slice is taken from the base of each trunk, to be used for counts and measurements of annual rings. The object was to seek a relation between age and girth, so it would have been preferable to have samples taken from breast height rather than the base, but this would not always have been practicable.

(3) For a selection of oaks covering a range of girths the thickness of bark and bast, and the approximate thickness of sapwood, were measured on auger cores taken radially at breast height. (The sapwood measurement was imprecise since the transition from sapwood to heartwood is not sharp.) Two cores were taken from each tree, on

radii approximately at right angles. Each core was started in a flat section of bark. The auger used, made by Moritz of Vienna, took a core 6 mm in diameter. The sample discs from (2) were treated in the same way.

(4) A sample was cut from the base of at least one stem on each grown-out ash stool felled since 1987, and samples of hazel were cut from diverse locations in the wood outside the small-scale coupes. Permission was obtained from English Nature for the taking of these hazel samples, since the whole of the Lower Woods is a Site of Special Scientific Interest, in which only approved operations may be carried out. The cutting of the ash stems had already been approved under the Reserve Management Plan.

RESULTS

THE OAKS IN CONTEXT

Table 1 gives the tree species, and total number of each, found in the study area. A large quantity of aspen seedlings appeared in one coupe after coppicing, derived from a tree outside the area. Most of the oaks are English Oak *Quercus robur*, though it seems that several genetic types are present and there may be hybrids of English Oak and Sessile Oak *Q. petraea*. The main concentration of Sessile Oaks lies outside the study area, though not far away.

TABLE 1. Tree species and numbers in the study area. For other than standard trees, the numbers are the counts of stools, not of individual stems. Trees felled since 1969 are included here, so as to present a picture of the wood as it was before reserve management began. See text for proviso on Wild Service.

Species	*Number*
Oak *Quercus* spp.	465
Ash *Fraxinus excelsior*	87
Wild Service *Sorbus tomentosa*	27
Field Maple *Acer campestre*	11
Poplar *Populus* sp.	6
Beech *Fagus sylvatica*	5
Birch *Betula* sp.	5
Alder *Alnus glutinosa*	1
Hawthorn *Crataegus* spp.	1

Almost all the ash is in the form of outgrown stems on coppice stools, which under the old regime would have been cut every 18 or 36 years. Some of the stools are of great size and complexity and apparently are of considerable age. The ash stems were left uncut during the first round of small-scale coppicing from 1969 to 1987 and have grown into substantial trees, each shading a considerable area. Most are being felled during the second round. Counts of annual rings on the basal sample disks all show that the stems had last been cut in the winter of 1928/29 or of 1929/30. It was noted that stems on a given stool might have very different thicknesses although being the same age. As well as the stools there are innumerable seedlings and pencil-thin saplings of ash, up to 2 m in height. These saplings were studied by Hendry *et al.* (1986), who showed that they range in age from one or two up to 25 years. Their growth has been suppressed by low light intensity and by competition for resources, and they await a gap in the canopy to enable them to spring into renewed growth.

To the wild service total should be added some dozen other stems felled recently during coppicing. This species forms extensive root systems from which groups of trunks may arise by suckering. Each such group forms a single organism, so the exact number of separate individuals involved is uncertain. Some wild service are on coppice stools, but many seem to have grown from root systems since the last commercial coppicing.

The largest of the few beeches are growing on the ancient woodbank and may be the last remnants of a hedge planted long ago as part of the coupe enclosure system (Martin & Taylor, 1995). The beeches in the interior are mostly near the woodbank, and may well have arisen as seedlings from the trees on the bank.

There is much field maple in the shrub layer or understorey, and the small number of trees of this species presumably arose from the growing out of some shrub stems. The poplars and birches have probably originated from seeds carried into the wood by birds or wind. Poplar growing on a commercial scale was attempted nearby in the period after the 1970s but proved to be uneconomic. The nursery beds near Lower Woods Lodge still exist, having grown into high-density plantations of poplar poles.

THE FORM OF THE OAKS

Most of the oaks are standard trees with straight, upright, symmetrical trunks, but at least one in eight have other forms. Some are obviously growing on low coppice stools, which are sometimes of considerable size and age. A few stools carry two or three growing stems, but most have only one, and appear to have been 'singled' at some time. Some carry also the butts of stems cut in the past, usually long enough ago for the bark and sapwood to have vanished, with no evidence of regrowth from the stumps. Others represent a later stage, in which the stool comprises a rim of living wood surrounding a core which is either rotten or hollow; in a few cases fresh shoots have appeared from the rim under the influence of the increased light level in the season or two after coppicing of the hazel.

Yet other examples belong to a still later stage in which most of the stool has rotted away, though vestiges are distinguishable at or just below ground level, with a single trunk still growing from one point on the periphery. Finally, where no overt trace of a stool remains, the curved butt of a single oak strongly suggests that it is not a standard but a stem from a vanished stool. In a few cases, two trees only a metre or so apart and with asymmetric butts, may both be stems from the same former stool, though we have excluded these from our stool count. There are also old stools, both of oak and of hazel, with no sign of life remaining; we think it likely that these were killed by the increased shading after the nineteenth-century plantings of standard trees (see below). Plate 1 shows examples of some of these types.

PLATE 1, opposite. Top: oaks with (left) bulbous and (right) curved butt, showing growth from former stools. Centre: stem with asymmetric base, alongside apparently dead stool (in fact, they share living underground tissue). Bottom: vestigial, dead stool 90 cm (the walking stick length) across.

As well as these low stools, there are a number of old oak stumps a metre or more high, hollow and often misshapen, with holes where stems have once been cut, and sometimes carrying a single thin stem at their apex; in a few cases the stump and the stem are still living. There has been much speculation as to the origin of these stumps, but so far we can offer no satisfactory explanation. Both the living stems and the stumps carrying them have been included in our data in Table 2 and elsewhere below, but stumps with dead or no stems have been excluded.

TABLE 2. Average densities of oaks in the coupes. The code letters refer to the map, Figure 1. Coupe U2 was a 1993/94 addition to U. The figures include both coppice stems and standard trees, and are based on a complete enumeration, not on sample counts.

Coupe	*Area, ha*	*No. of oaks*	*Oaks/ha*	*Code letter*
1987/88	0·24	68	287	none
1988/89	0·21	50	239	N
1989/90	0·21	34	162	C
1990/91	0·19	37	196	P
1991/92	0·27	47	175	T
1992/93	0·22	75	341	U
1993/94	0·16	57	353	U2
1993/94	0·16	34	212	L
1994/95	0·13	40	317	X

Here and there are the butts of standard oaks felled during reserve management operations to provide fencing material and to admit light to the understorey. For our present purposes we are concerned with the wood as it was before the reserve was established, so these felled trees have been included in our tree counts when estimating stocking density, and in our growth data (using reconstructed girths - see below) where necessary. There are a few older and badly decayed standard butts, from earlier fellings. We cannot reliably date these, and so have excluded them from our data.

OAK STOCKING DENSITY

In 1969 the whole study area contained a total of 461 oak standards and coppice stools, and four younger standards are now present, making a total of 465 in 1·79 ha or 260 per ha (108 per acre). Included in the total there are 60 which we consider on strong evidence to be coppice stools; this is a minimum figure as we have been conservative in our selection and almost certainly have failed to detect some, nor have we included the dead coppice stools and stumps mentioned above. So, averaged over the whole area, the density of living oak coppice stools or stumps is 33·5 per ha (14 per acre), and the density of the remaining 405 oaks is 226 per ha (94 per acre). We show later that the density of coppice stools was once higher than it is now, though we have not been able to give definite figures for the difference. The density of standards is very high.

There is a visual impression that the distribution of the oaks is patchy, and to demonstrate this Table 2 gives the average density within each coupe. More sophisticated "plotless" methods of measuring density (Diggle *et al.*,1976; Bonham, 1989) have been used to examine density variations, but an account of these is deferred to a future paper dealing with the details of individual tree locations. Meantime Table 2 shows that areas roughly similar in size can vary by 100% in the number of oaks they hold.

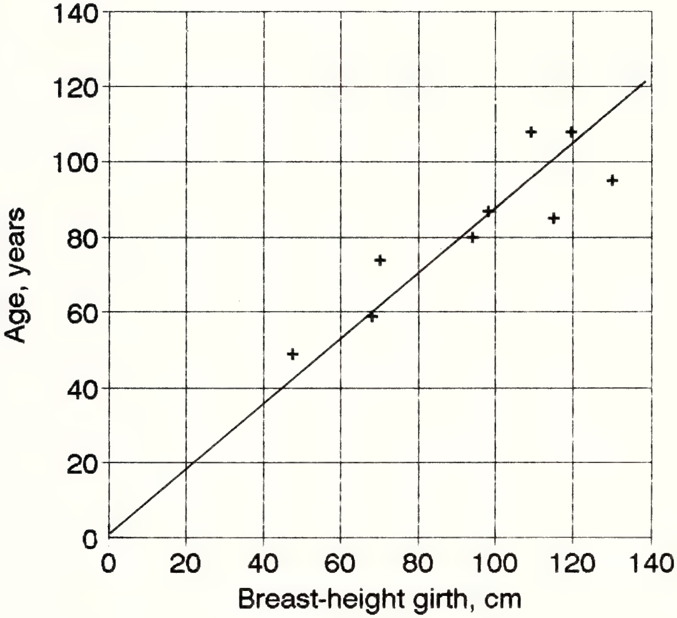

FIGURE 2. Relation between age at felling (determined by ring counts) and breast-height girth, for oaks in coppiced area felled since 1987. The slope of the regression line constrained through the origin is 1·15 cm bhg/year, with standard error 0·05 (on 9 degrees of freedom).

ESTIMATED RATE OF GROWTH

A necessity in studying the history of the wood is some means of estimating the ages of the trees. Figure 2 is a graph of the age at felling, determined by ring counts on basal specimens, of all the oaks felled since the start of this study plotted against the girths at breast height of the corresponding trunks.[2] The straight line corresponds to an increase in bhg of 1·15 cm (0·45 inches) per year, close to Mitchell's (1974) rule of thumb for woodland trees of half an inch girth increment a year. This proportional relation has been used to estimate the ages of all the oaks encountered.

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[2] Further oaks, earmarked for felling, will give more data in due course. The requirements of safety legislation mean that felling is done by trained workers employed by Gloucestershire Wildlife Trust,

It is emphasised that the data relate to different standard trees cut down at different ages, not to different stages in the growth of a single tree. Each point corresponds to the mean growth rate of one stem, averaged over its whole growing life, so that the older trees may well have spent the first part of their lives under different conditions of climate or of caterpillar attack from the younger ones. However, they were all growing in the same wood, and this is the best estimate currently available.

Stems regrowing on a coppice stool would be expected, at least initially, to grow at a faster rate than standards, as they can call on all the resources of a large and well-established root system. Since no oak coppice stems have yet been cut during the study period, no direct evidence as to differences in growth rate from that of standard trees is available and the same value has been used as for standards.

RATE OF GROWTH IN THE IMMEDIATE PAST

To give a direct check on rate of growth, a sample of 30 oaks measured on 6 July 1988 were re-measured in February 1995. The need for this had not been foreseen in 1988, so the precise positions of the first measurements had not been marked. However, the second set was made in the same way, and standing in approximately the same place, as the first. One pair of measurements was discarded as a large ivy stem was present on the second occasion but not the first. The 29 others all showed increases, though as might have been expected these were very variable, ranging from 0·7 to 13·3 cm. Nevertheless the average increase of 6·5 cm had a satisfactorily small standard error (SE) of 0·60 cm. Assuming, as is likely, that three-quarters of the radial growth in 1988 was complete when the initial measurements were made, the difference corresponds to 6·25 seasons' growth, so the average annual increase in girth was 6·5/6·25 = 1·04 cm per year with SE 0·096, less than but not far from the value derived from the felled trees. The girths in 1988 ranged from 58 to 200 cm, and the increments seemed to be unrelated to the tree sizes, in accord with Mitchell's "rule".

Steele & Welch (1973) gave data for ten oaks in Monks Wood National Nature Reserve which were girthed at marked points annually for five years. The initial girths ranged from 134 to 190·5 cm, and the five-year increments ranged from 3·1 to 8·6 cm. The average girth increment was 1·08 cm per year, in close agreement with our value. In fact, the variability in each of the three sets of data is such that the three estimates of growth rate are not statistically distinguishable.[3]

BARK THICKNESS

The relation found between girth and thickness of "bark" - actually bark plus bast - determined from measurements on the auger cores is shown in Fig. 3. The line shows the least-squares relation, constrained through the origin. Its slope is equivalent to

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whose schedule will probably not allow further felling in Lower Wetmoor before winter 1996/97.

[3] Comparing $x = 1{\cdot}15$ with SE 0·05 (9 df) and $y = 1{\cdot}04$ with SE 0·096 (28 df), $t = 1{\cdot}01$ with 37 df, using B. L. Welch's approximation for the degrees of freedom of the difference (Welch, 1947), so P = 30% approximately (2-sided test). The Steele & Welch mean of 1·08 lies between the others and has a larger standard error (0·13, by our calculation, on 9 df), so is not significantly different from either.

0·103 mm thickness per 1cm bhg. This has been used to estimate the thickness of bark missing from stumps or stem butts cut some time ago, so that a complete girth value could be inferred from the girth of the residual stump. As with the girth data in Fig. 2, the bark thickness measurements were made on different trees of different sizes (and, by implication, of different ages), but are here being applied to a single tree at different stages of its growth. The justification for this is that the trees to be measured were chosen at random, the criterion being only that they covered a wide range of girths.

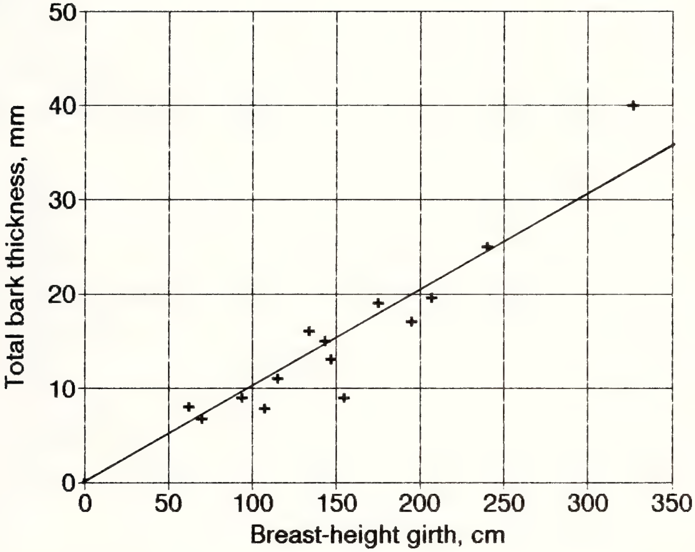

FIGURE 3. Relation between breast-height girth (cm) and thickness of "bark" (actually bark plus bast) (mm). Each value is the mean of two measurements along radii at right angles. The regression line, constrained through the origin, has slope 0·103 mm bark per 1 cm bhg, with SE 0·005 on 13 df.

A RECONSTRUCTED GROWTH CURVE

The annual rings in a tree's cross-section give a complete record of its history. Variations in the ring widths show changes in the rate of growth and so throw light on past conditions - an aspect of our data that will be reported in the future. Also, the circumference of a ring shows the girth of the trunk at the end of that season's growth, though of course excluding its 'bark'. As an experiment, the growth curve of a single standard tree was reconstructed on the basis of ring measurements on a sample disc, using the relation from Fig. 3 to add an appropriate allowance for bark at each age. The sample came from a 108-year-old oak felled in 1992. It was chosen as being the most symmetrical of the specimens available, and having its growth centre not far from its geometric centre, so that its annual rings were not far from circular. The major and minor radii of each growth-ring were measured and averaged to give a single value for each year, to which was added the appropriate allowance for bark thickness, estimated from Fig. 3, and then converted to a notional girth assuming the section to be circular.[4] The graph of these girths against the corresponding ring ages was essentially a straight line[5] corresponding to an average girth increment close to 1 cm per year, with a few short periods of faster or slower growth.

THE AGE RANGE OF THE OAKS

Overall, about two-thirds of the measured oaks were under 120 cm in girth, corresponding from Fig. 2 to estimated ages, when measured, of under 105 years. The smallest, 20 - 25 cm, corresponded to 17 - 22 years while the largest, 190 - 240 cm, corresponded to ages of 165 to 208 years. We emphasise that in the case of coppice stems, or stems inferred to be growing from former stools, the ages are those of the stems, not of the stools from which they grew, which would be very much greater - some stools, with girths of 3 m or more, could be over 400 years old.

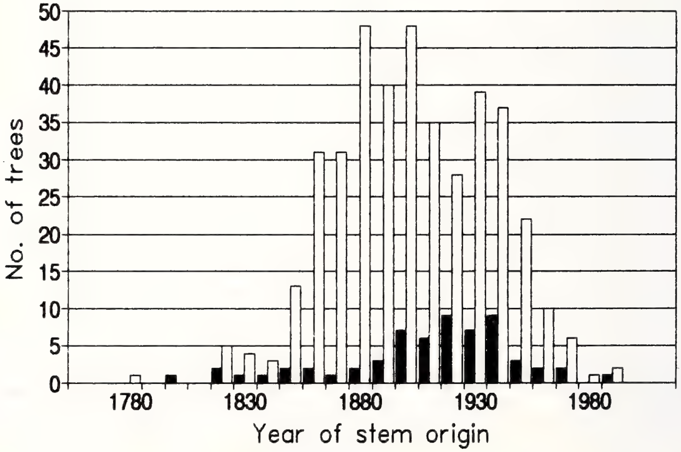

FIGURE 4. Estimated 'birth years' of standards and coppice stems, in ten-year intervals. Filled columns, coppice stems; open columns, standards. *Note*. A few of the standards may in reality be coppice stems.

The fact that our measurements have been made during seven calendar years, during which period every tree has made significant growth, complicates the discussion of age. So as to simplify interpretation the ages estimated from the girths were converted to equivalent 'birth dates' by subtracting each age from the year in which the measurement was made. Fig. 4 shows the distribution of these 'birth dates', grouped in ten-year periods, for the coppice stools and the remainder separately. It summarises our data on the management of the wood over the last 200 years.

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[4] Since the added 'bark correction' is proportional to bhg, it is easy to show that the whole process is equivalent to calculating overall girths by multiplying the ring radii by 6·72 instead of by $2\pi = 6{\cdot}28$.

[5] The least-squares regression line constrained through the origin had a slope of 0·976 cm/year, with SE 0·002, on 107 d.f. An unconstrained regression gave negligibly different results.

DISCUSSION

RATE OF GROWTH

Our measurements in 1988 repeated in 1995 give an estimated annual girth increment close to 1 cm, which is lent credence by the results of Steele & Welch (1973) at Monks Wood, Huntingdon, achieved in a similar way (though from fewer trees and after a slightly shorter interval.) On the other hand our data from the felled trees, Fig. 2, gave an average increment of 1·15 cm/year. As we pointed out above, the variation in these sets is such that their difference is not statistically significant. However we chose to use the Fig. 2 result to produce Fig. 4, because it gives a growth rate averaged over the whole lives of the trees in question; a faster growth rate would be expected in early life, and also for a few years after each coppice coupe had periodically removed competing understorey vegetation. In fact, the average of the two estimates (weighted by the reciprocals of their variances) is 1·13 cm/year, and the use of this value would scarcely have altered Fig. 4. We await with interest the felling of further trees, to provide a firmer and more broadly-based estimate of growth rate.

Admittedly our reconstructed growth curve on a single Lower Wetmoor tree also gave a slope very close to 1 cm/year, but we should wish to reconstruct several more histories before placing too much weight on this result. The scatter about the regression line in Fig. 2 shows that individual trees can have life-time girth increment rates greater or less than 1·5 cm /year.

THE STANDARD TREES

The age distribution of the standard trees (the open bars in Fig. 5) tails off at both ends. Some of the oldest standards, which form the left-hand 'tail' of the distribution, are along the border of the main ride. They date from the late eighteenth and early nineteenth century, a period when the layout of many old woods was modified, with wider, straight rides replacing the foresters' tracks. These trees have presumably been left as an ornamental feature.

A coppice-with-standards oak wood managed in the traditional way would at any time contain standard trees of various ages. Whenever the underwood was cut (say every 18 years) some standards would be culled from each age class, leaving the best, and saplings would be left growing to replace them in due course. If this was the system being followed, then in 1929/30 (with no hint that the coupe then in progress would be the last), some standards would have been felled and saplings left to grow in their place ready for the expected 1947/48 coupe. The relevant bars at the right-hand side of Fig. 4 total about 60 trees originating in this period. The few making up the extreme right-hand end of the histogram are saplings that have appeared since about 1950.

According to Evans (1984), the traditional stocking for standards per hectare was 50 in their first rotation (up to say 18 years old), 30 in their second or third rotation (18 to 54 years), 13 in their fourth (54 to 72 years) and 7 in their fifth to sixth (72 to 108 years). Under a system like this, standards much older than 108 years would be exceptional, and Fig. 4 shows this to be the case. Converted to the 1·8 ha of the study area, the equivalent numbers in the four classes would be about 90, 55, 23 and 12, totalling 180 - a distribution with a peak at the right-hand (young) end and tailing off sharply with increasing age.

Above we found 60, not 90, for the youngest age-class (1930 to 1947), so clearly the standards do not entirely follow this 'traditional' distribution of ages. Moreover, the central, main part of the actual distribution in Fig. 4 is not even roughly like the 'traditional' one, but is much more uniform. The only reasonable explanation we can find for the difference is that many trees must have been planted from 1850 onwards, probably at least until 1910, and furthermore that the planting was done progressively, and not in one or two large operations. It was over this period that changes in techniques of packaging and of building and ship construction, and above all the increasing availability of coal and coke fuel, meant that the future for coppice produce as against oak timber must have begun to look bleak (Martin & Taylor, 1995). In our view the plantings represented a deliberate move from management as coppice-with-standards towards high forest, with the object of producing a varied age-structure from which timber trees could be harvested progressively, perhaps from around the year 2000 or 2050 onwards.

Alongside the growth of these planted standards the old oak and hazel coppice rotation obviously continued, though the great increase in tree density and so in shade which the plantings brought about would have eventually affected the coppice structure. The weaker oak stools would be shaded out and killed, as would some of the hazel stools (remains of dead stools of both species survive). We have found stumps that could be associated with the felling of standards in the immediate pre-Reserve era, and we suspect that the 'normal' practice of thinning standards was continuing, though being phased out. We might hazard a guess that this is at least part of the reason why we find only some 60 trees dating from 1930-1947 instead of the 'expected' 90.

It might at first seem perverse to suggest that standards were still being felled periodically during a period of conversion to high forest, but we think there is a convincing reason. Under the traditional system the older standards present in 1930 would have dated from around 1820 to 1880, i.e. before the start of the plantings or when the planted oaks were still young. Therefore these older trees would have spent their formative years in a coppice-with-standards environment, and would have developed the spreading main branches which this produces and which take up much more space than do the crowns of trees grown at high forest densities. The trees planted from 1850 onwards would not have grown large enough to restrict the growth of these older standards, which would have been periodically harvested as usual as part of the move to high forest.. Some large oaks with very spreading, gnarled branches probably represent the last survivors of this group.

In view of the above, the following quotation (Ward, 1954) is of interest; we know of no evidence connecting Lower Woods oak with shipbuilding, but house-building too had uses for curved timbers.

> 'This wide spacing [of traditional coppice-with-standards] permitted trees to spread and to make those crooked timbers which shipbuilders

> required ... Since 1862 we have not required the same kind of oak for shipbuilding: for most purposes straight, knot-free timber is needed - and the longer the better. A full mature crop of oak should number not twelve or twenty trees an acre but something like fifty to seventy. And if the soil and site are favourable, the oak should be fit to fell before it is 200 years old. ... The relatively slow growth of oak would mean some time-lag in the adjustment of a sylvicultural system to new needs even if most landowners had a lively forest sense (which they have not), and no bias towards inertia. As things are, much oak has been and is being grown as though the needs of 1960 and 2000 would be the same as those of 1560 and 1600.'

In our view the plantings in Lower Wetmoor in the second half of the nineteenth century were such an adjustment, started as soon as the need had become apparent to the then owners..

THE COPPICE CYCLE

From Fig. 4 (the filled bars), the bulk of the oak coppice stems originate from around 1890 to 1930, for which we offer the following explanation. Working back from the winter of 1929/30, using an interval of 18 years, previous coupes would have been in 1911/12, 1893/94 and 1875/76. On each of these occasions oak stems of various ages would have been harvested and others left to grow on for two or three or, rarely, four cycles, to provide poles for various purposes not justifying the sacrifice of standard trees (Martin & Taylor, 1995). With the end of commercial coppicing, they remained uncut, and still do so. The long left-hand 'tail' of the coppice distribution contains the living butts still carrying single stems, referred to earlier.

ACKNOWLEDGEMENTS

We are grateful to Miss R. M. Martin for preparing the map which is the basis of Fig. 1, and to Dr M. H. Martin for many helpful discussions and for the loan of the sampling auger (though we alone are responsible for the use made of it).

This study is dedicated to the memory of the late Morley Penistan, who when Chairman of the Gloucestershire Trust for Nature Conservation was responsible for the acquisition of the Wetmoor Reserve, who as Chairman of its management committee guided its care for many years (and invited S. M. T. to join the committee at its inception in 1967), and who as a friend taught us much about trees and woods.

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THE EFFECTS OF COPPICING ON THE VEGETATION OF THE FIELD AND GROUND LAYERS OF AN ANCIENT WOODLAND, LOWER WETMOOR WOOD

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INTRODUCTION

Many broadleaf trees are able to regrow from cut stumps; this capacity has led to the practice of regularly harvesting the regrowth, or 'coppicing'. The use of coppice and the beginning of woodland management can be traced back to Neolithic times; much of the evidence for this comes from the Somerset Levels where there has been extensive excavation of well-preserved timber trackways (Morgan, 1984; Rackham, 1977, 1979). Most of the ancient oak-woods in the British Isles have survived as a result of human intervention in the past, and this has been primarily through management in the form of coppice-with-standards (Marren, 1990). For a review of this form of woodland management, its former importance and its decline, see Martin & Taylor (1995). In summary, a typical coppice-with-standards oak wood consisted of underwood mostly of hazel *Corylus avellana* (the coppice) which was cut on a rotation of (5)-8-18-(40) years and grown beneath a canopy of oak 'standards' which were left to grow for 60 - 100 years or more. The standard trees were planted more or less densely, depending on the type of timber required - trees growing far apart produced spreading branches that yielded the curved members needed in construction works, whereas trees planted close together grew with taller and straighter trunks from which long straight beams or planks could be cut .

The demand for coppice products declined after the 1914-18 war and labour-intensive coppice management was increasingly abandoned as being uneconomic. Many woods were grubbed, while in others the stools were left to grow. However, with the rise of the nature conservation movement from the 1960s onwards many ancient woodlands containing abandoned and overgrown coppice became nature reserves. In consequence coppice management has often been re-introduced in whole or in part, both in National Nature Reserves and in local reserves managed by county trusts (Watkins, 1990; Rackham, 1980; Peterken, 1993; Marren, 1990, 1994; Fuller & Warren, 1990), so as to preserve knowledge of the technique and to benefit from its effects, which include a marked improvement in the quality of the habitat. The present study examines details of the effect of coppicing on certain aspects of the vegetation.

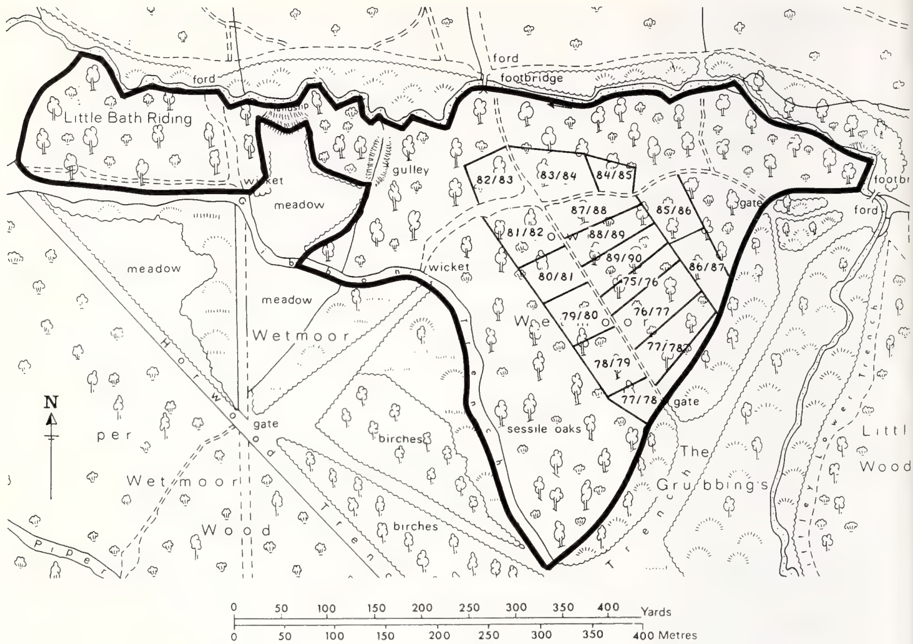
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FIGURE 1. Map of Lower Wetmoor Wood, part of Wetmoor Nature Reserve, Avon, showing position, shape and relative size of areas under coppice management. The figures in each compartment indicate the winter when last coppiced (e.g. 88/89 indicates area last coppiced in winter of 1988/1989).

Lower Wetmoor Wood is the largest component of the present Wetmoor Nature Reserve and was last coppiced in 1929 - 1930. It was acquired by the Gloucestershire Wildlife Trust in 1967, and coppice management was re-introduced on a modest scale in the winter of 1969/70. A coppice cut or 'coupe' has been made each year since, mainly through the good offices of the Bristol Conservation Volunteers. Initially an eighteen-year cycle was used, but from the start of the second round in 1987/88 the boundaries of some plots were modified so as to aim at a fifteen-year cycle.

The general nature of the changes in vegetation following coppicing is well-known, in particular from the classic study by Salisbury (1924) in Hertfordshire. However, in any particular case the details are subject to the effects of local soils, climate and relief and the species and planting density of the standard trees. Patrick & Hendry (1984) described aspects of the then coppice cycle in Lower Wetmoor. In 1990 the opportunity arose for a more comprehensive survey of the effects of coppicing on the field and ground layer vegetation (Martin, 1991), and this paper describes some of the more important results.

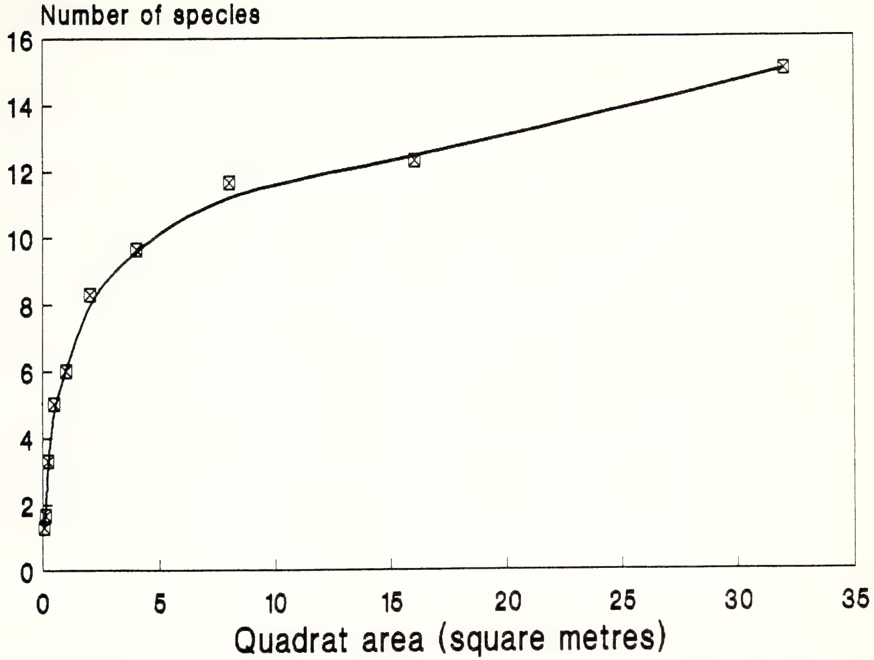

FIGURE 2. Results of a minimal area study showing number of species recorded in a progressively expanding quadrat area.

METHODS

The general history and ecology of Wetmoor Nature Reserve have been described by Hendry (1980) and Martin & Taylor (1994, 1995). An account of the interpretation of past coppice management can be found in Taylor & Taylor (1995). Fig. 1 shows the locations and coppicing dates of the areas used in the coppice cycle at Wetmoor. A preliminary study showed that a quadrat of 4m^2 area recorded 67% of the species of higher plants in the field and ground layer vegetation, relative to a sample area of 32 m^2 (see Fig. 2), so for ease of sampling a quadrat size of 4m^2 was adopted for the survey. During the summer of 1990 each of the 15 coppiced areas was sampled in the following way. Three 2 x 2 m quadrats were placed randomly, using random number tables and a pair of axes at right angles through the area. Within each quadrat the percentage area covered by each of the higher plant species was estimated, also the percentage cover of bare ground, leaf litter and total cover by mosses. The height of bramble growth was recorded and the height and nature of the hazel regrowth were noted.

The main mosses encountered varied little throughout the survey: *Fissidens taxifolius, Thuidium tamariscinum, Eurhynchium praelongum, E. striatum* and *Thamnobryum alopecurum*. *Mnium hornum* and *Brachythecium rutabulum* also occurred but were mostly restricted to fallen branches and old stumps. Liverworts and lichens were very rare and never contributed significantly to the percentage cover in the quadrats. The percentage cover of all the different moss species within the quadrats was aggregated to provide one value.

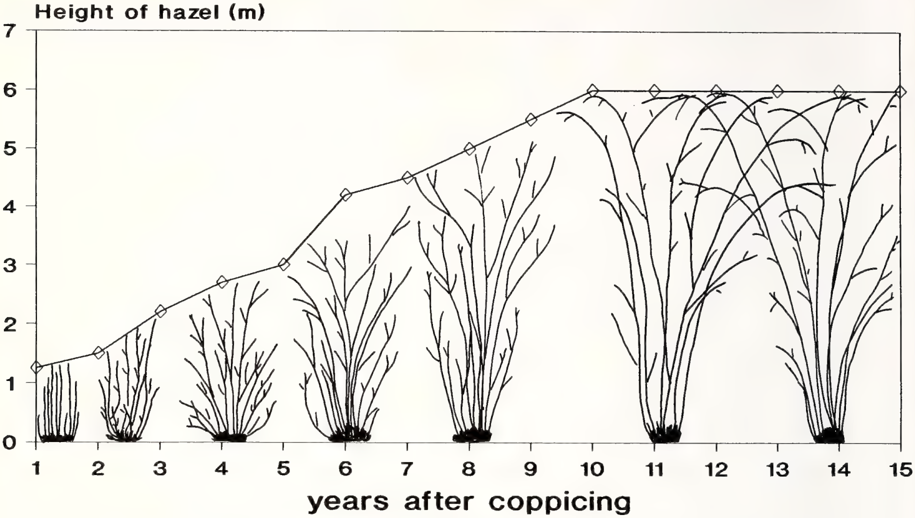

FIGURE 3. The regrowth of hazel coppice with age since last coppicing. The curve shows the average height, in metres, of hazel in each coupe (age in years) and a diagrammatic representation of the branching form of the regrowth.

Attempts to assess the homogeneity of the habitat in the different coupes were restricted to examination of the soil. Surface soil pH, loss-on-ignition and moisture content were measured in each coupe. A surface pH meter was used to measure soil pH *in situ*, in surface scrapes puddled with deionised water. Five measurements of pH were taken in each quadrat (i.e. 15 measurements per coupe). Percentage moisture content was measured by drying soils at 95°C for 36 hours, with a final two hours at 105°C. Bulk samples consisting of three cores (each 2·3 cm in diameter x 5 cm deep) from each quadrat were used, giving three measurements per coupe. Loss-on-ignition was used as a crude measure of soil organic matter; the samples used in the moisture content determinations were ground to pass a 2 mm mesh seive, then redried at 105°C. Finally 1g samples were placed in a muffle furnace at 550°C for two hours (Allen, 1989) and the loss in weight due to ignition was calculated after cooling, giving three values per coupe.

Additional data were collected to contrast meteorological conditions in the oldest and youngest coupes. Relative humidity, temperature, windspeed and light intensity were measured on a single day in August. The results are summarised in Table 1, the caption to which outlines the methods used.

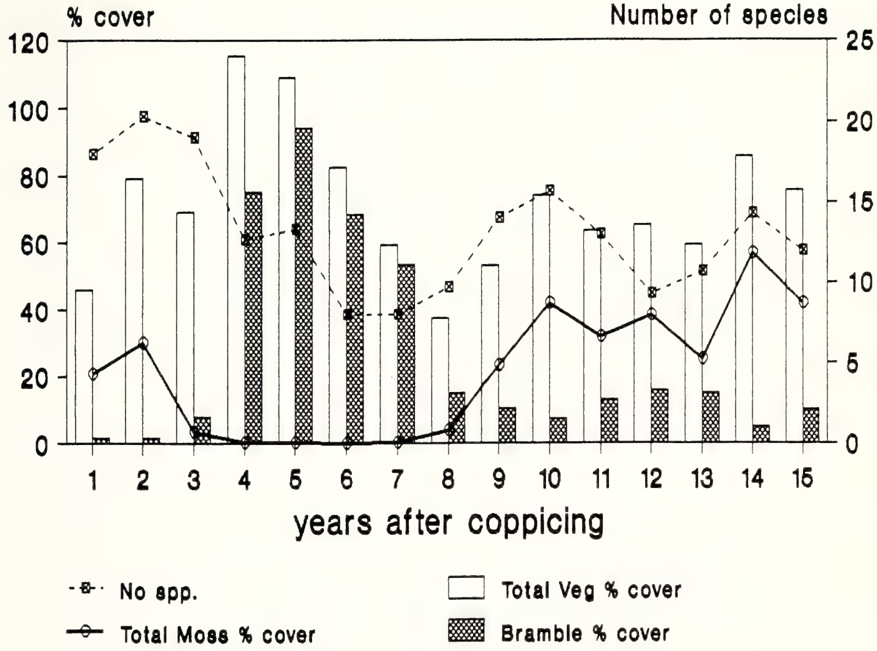

FIGURE 4. Relationships between years after coppicing and percentage cover for all species (Total Veg.), bramble and moss (Total Moss). Changes in average number of species recorded (dashed line) are also shown.

RESULTS

The results of the survey are presented graphically to show the major trends apparent in the vegetation during the coppice cycle. A total of 51 species of higher plants were recorded in the quadrats, excluding woody species more than one metre tall. It should be remembered that the survey was undertaken during the month of August when some spring species may not have been apparent.

The graph of hazel regrowth (Fig. 3) shows that one year after coppicing the average height of the new shoots was 1·2 m. Extension growth predominated until about year 10, but then further increase in height virtually ceased. Progressively from years 8 - 15 lateral spread of the hazel increased, so that by year 12 a complete shrub layer canopy had been re-established.

Fig. 4 shows the relationship between total vegetation cover by all field and ground layer species, the cover by moss, and cover by bramble (*Rubus*). There are several important features to note. First, total cover by vegetation reaches a peak in years 4 and 5, but in years 4 - 7 bramble forms a very large proportion of the total. Bramble shows

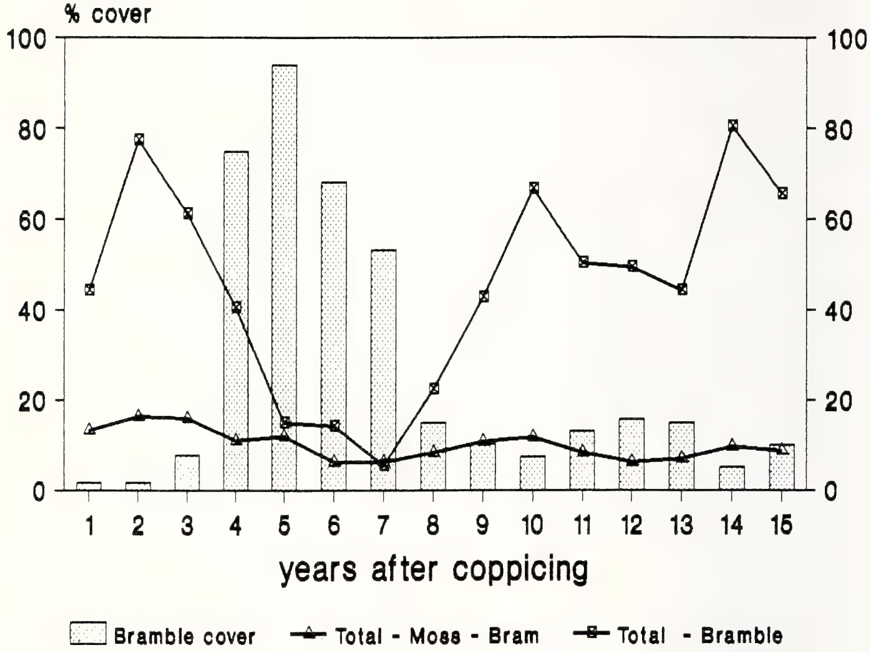

FIGURE 5. Relationships between age of coppice an percentage cover by brambles (Bramble cover), total vegetation cover minus bramble cover (Total - Bramble) and total vegetation cover minus bramble and moss cover (Total - Moss - Bram).

a distinct pattern of change in abundance: it increases markedly from very low values to over 60% cover at four years after coppicing, then remains dominant in the field layer until about years 7 - 8, after which it declines to values around 10%. Secondly, there appears to be an inverse relationship between cover by moss and by bramble: when bramble is dominant in the quadrats the cover by moss is very low; but once the dominance of bramble declines, moss cover increases to generally more than 50%.

These two features appear to be best explained in relation to the light regime and the regrowth of hazel (Fig. 3). It appears that, in Lower Wetmoor Wood, bramble needs three years of the high light conditions that follow coppicing in order to build up sufficient vigour to allow it to dominate the field layer. Then, by year 7 or 8, the hazel has grown clear of the bramble and becomes dominant in its turn, its canopy casting sufficient shade to suppress bramble growth. Woodland moss species are tolerant of some shading, and are able to survive in the more open conditions existing below a hazel canopy but not in the deep shade below the dense overgrowth of bramble.

Thirdly, it should be noted that, apart from these changes in brambles and moss, the percentage cover by other species (see Fig. 5) shows only slight variation - from around 15% in the early years to around 10% in the later stages of the coppice cycle. Fig. 4 also shows for each coupe the average number of species recorded in the quadrats, which is greatest two or three years after coppicing but declines as bramble becomes dominant and is at its lowest after three years or so of extensive bramble cover.

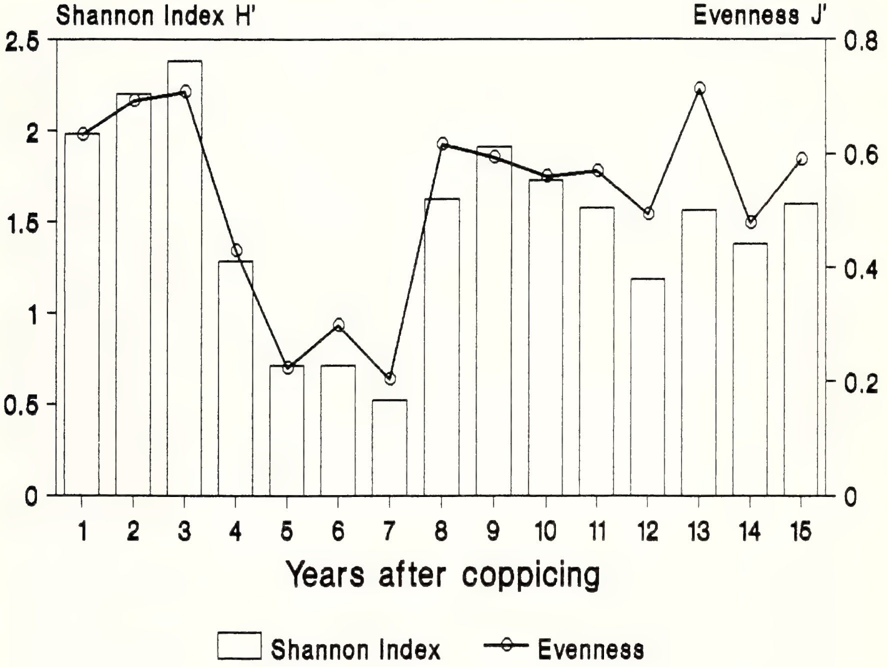

Figure 6. Changes in species diversity, Shannon index and evenness with age of coppice. See text for explanation of indices.

Two aspects of interest in connection with any assemblage of species are **diversity** and **evenness**. Diversity depends both on the number of species present and on their relative proportions; one might say that in a diverse population, if two specimens are taken at random there will be a reasonably high chance that they will be of different species. The degree of evenness is a measure of the extent to which the species have similar abundances. If most of them are present in similar proportions then evenness is high.

A commonly-used measure of diversity is the Shannon Index H' (Khinchin, 1957). Its value usually lies between 1·5 and 3·5 (Magurran, 1988), with the higher values indicating greater diversity. H' would have its maximum possible value if all the species were present in equal amounts (i.e. if their distribution were completely even). An index of evenness J' can be calculated by expressing the actual value of H' for the sample with this maximum possible value, so that J' must lie between 1 (for a completely even distribution) and near zero[1]. Fig. 6 shows the values of H' and J', and confirms that diversity is lowest when bramble is dominant.

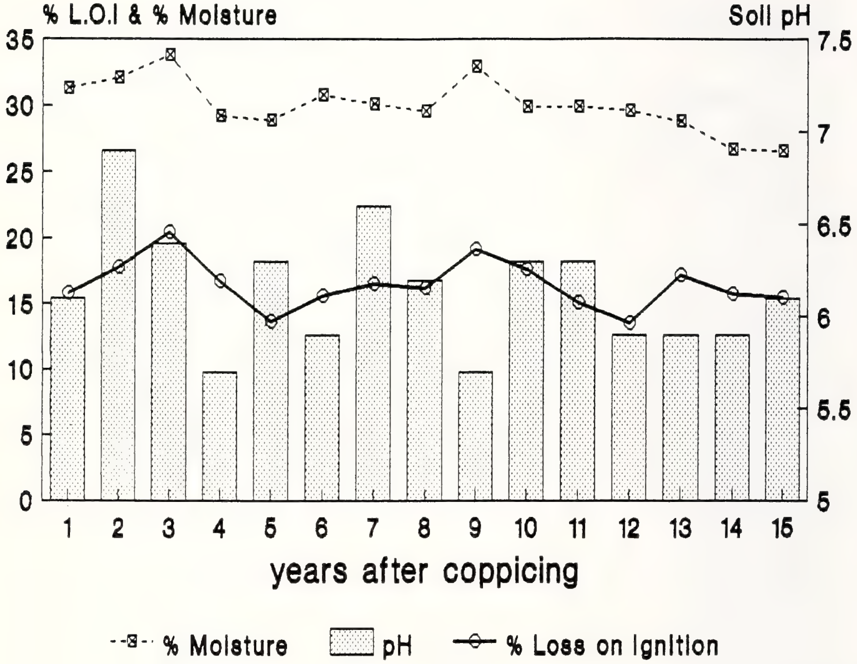

FIGURE 7. Variation with age of coppice of soil pH, loss-on-ignition as a crude expression of soil organic matter, and percentage soil moisture contents, all measured during August 1990.

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[1] The Shannon Index is calculated by finding, for each species in turn, the proportion p that it forms of the total sample, multiplying p by its natural logarithm, adding the results for all the species present, and for convenience changing the sign of the total (since the values of the logarithms are all negative):

$$H' = -\Sigma(p.\log p).$$

The maximum value of H', when n species are present in equal proportions 1/n, is log n; so

$$J' = H' / \log n.$$

Fig. 7 shows the variation in the measured soil properties - pH, loss-on-ignition and moisture content - and makes it clear that none of them varies greatly across the age span of the coupes. Climate-related measurements in the oldest and youngest coupes (see Table 1) show some significant differences: much lower light intensities at 1m above the ground, lower wind speeds, higher relative humidity and marginally higher temperatures occur in the oldest coupe. Whilst these measurements were from adjacent coupes they were made on just one day during August and the results should therefore be regarded only as indicative of differences.

DISCUSSION

The results of this investigation show trends generally similar to those of other studies of comparable woodland habitats elsewhere in Britain, e.g. the classic study by Salisbury (1924) in Hertfordshire and that reported by Ash & Barkham (1976) who described post-coppicing changes in the field layer of a Norfolk woodland. Coppicing causes sudden changes in the micro-climate of the area; the most dramatic effect of the removal of the shrub canopy is that much higher light intensities reach the woodland floor and its vegetation.The response of brambles to increased light conditions following coppicing is well known, although according to Rackham (1980) their dominance may be related to soil pH. Rackham comments that on acid soils (having pH 3·5 - 4·5) coppicing stimulates growth of brambles already present. On less acid and calcareous soils coppicing causes the sudden appearance of brambles, which are less tolerant of shade and, by implication, have a limited period of dominance. Fig. 7 shows that at Wetmoor the soil pH values would be in Rackham's 'less acid' category.

The data collected at Wetmoor Nature Reserve are not changes that occur in a single coppice coupe over time but are changes seen in a series of different aged coppiced areas examined at a single time. Thus it is possible that variation between coupes might affect the results. Nevertheless examination of areas last coppiced 10 to 15 years previously shows that they still retain evidence, in the form of dead stems, that brambles were at one time much taller and denser than at present, so it is reasonable to assume that the patterns of change illustrated here are consistent over time.

The dominance of brambles in the Lower Wetmoor coppice cycle should also be seen in respect to the current stocking of the oaks that form the tree canopy layer. They are almost certainly much more dense than they were when Wetmoor was managed for economic production of underwood, and give a degree of canopy cover considerably more than the 40% recommended for broadleaf silviculture (Watkins, 1990). There are therefore legitimate discussions about whether or not more standard trees should be removed. This would certainly allow more light to penetrate the woodland structure, which should invigorate the shrub layer of hazel coppice and the field layer vegetation.

However, the results of the current survey suggest that it would also enhance the growth of brambles. Mason & Long (1987), in a study of coppicing in Bovington Hall woodlands, Essex, found that "an explosion of bramble" followed coppicing and that the predicted encouragement of attractive spring flora failed to materialise. There, growth of bramble was listed as a disadvantage of coppicing; photographs show that coppicing left the woodland with very sparse canopy cover compared to that at Wetmoor. At the other extreme, regrowth of the coppice may be poor if too many standards are present (Fuller & Warren, 1990). Care is therefore needed to ensure that management of Wetmoor in the form of removal of standard oaks does not detract from the nature of the current woodland habitat by encouraging longer term dominance by brambles and the reduced species diversity that accompanies such dominance. Certainly the prospects of needing to control brambles in conditions of much reduced canopy cover by the methods suggested by Watkins (1990), namely annual cutting or use of the general herbicide glyphosate, are unattractive. It is also pertinent to remember that the Gloucestershire Wildlife Trust acquired the wood as "the last example of high forest oak woodland in the Vale of Berkeley" rather than as an example of traditional coppice-with-standards.

TABLE 1. Data showing comparison of conditions in the oldest coupe (15 years since coppicing) and the youngest (cut winter 1989/90). Windspeed was measured using a hot-wire anemometer, with the probe held 1m above ground level; readings were taken at 10-second intervals for 3 minutes. Light intensity (irradiance as photosynthetically active radiation, PAR, i.e. wavelengths 400-700 nm) was measured as the reflectance 1m vertically above a white card (1×0 x 0×8m) placed on the ground, during a spell of uninterrupted sunshine. Temperature and relative humidity were measured using a portable thermohygrometer with the probe held 1m above ground level; readings were taken simultaneously in each coupe at each of 10 random sites along a transect. Relative humidity, temperature and windspeed were measured on two separate occasions (A and B) during the same afternoon. Data are means ± standard errors; *, **, *** indicate statistically significant differences between coupes at 5%, 1% and 0.1% levels of probability respectively.

		Oldest coupe		*Youngest coupe*
Light Intensity (μEinsteins m^{-2} sec^{-1} PAR) (n = 10)		23·3 ± 3·8	**	274·1 ± 56·2
Windspeed ($m\ sec^{-1}$)	A	0·52 ± 0·08	**	0·98 ± 0·12
	B	0·58 ± 0·08	***	1·20 ± 0·12
Relative humidity (%) (n = 10)	A	57·2 ± 0·9	*	54·0 ± 0·3
	B	59·1 ± 0·5		57·9 ± 0·3
Temperature (deg. C) (n = 10)	A	16·8 ± 0·1		16·7 ± 0·1
	B	16·2 ± 0·1	*	16·5 ± 0·1

The re-introduction of regular coppicing in Wetmoor has provided an ideal opportunity to study the effects of coppicing, and many student groups have used Wetmoor both for project work and for class exercises. There is further scope for studying the effects of coppicing on small mammal populations and on the ground invertebrate fauna. Such studies would be welcomed. Work elsewhere suggests that overall abundance of invertebrates correlates well with the increase in plant growth in the years immediately following coppicing (Steel & Mills, 1988; Greatorex-Davies & Marrs, 1992). There is already an extensive list of invertebrate species for Wetmoor (Martin & Taylor 1994), which will also facilitate such studies.

ACKNOWLEDGEMENT

We wish to express our thanks to Mr S. M. Taylor for help and constructive comments during preparation of this paper.

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